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NUCLEAR ENERGY

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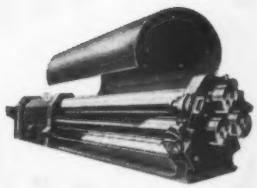

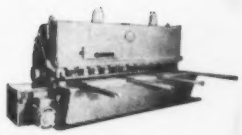

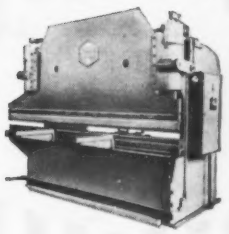

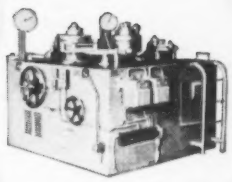

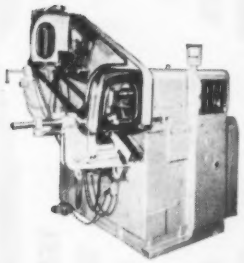

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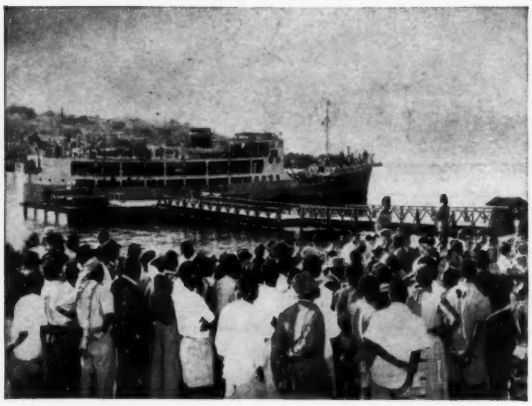

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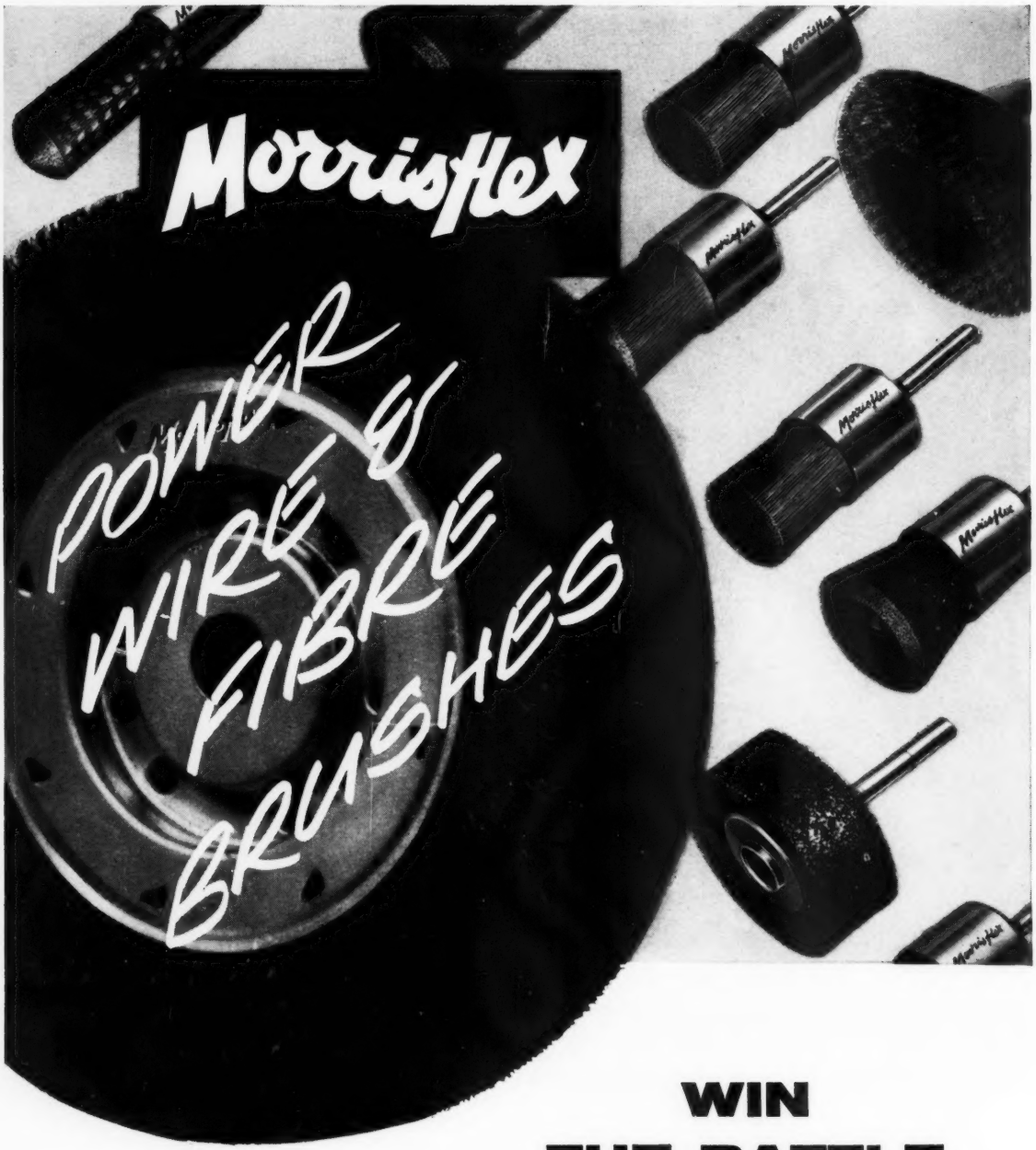

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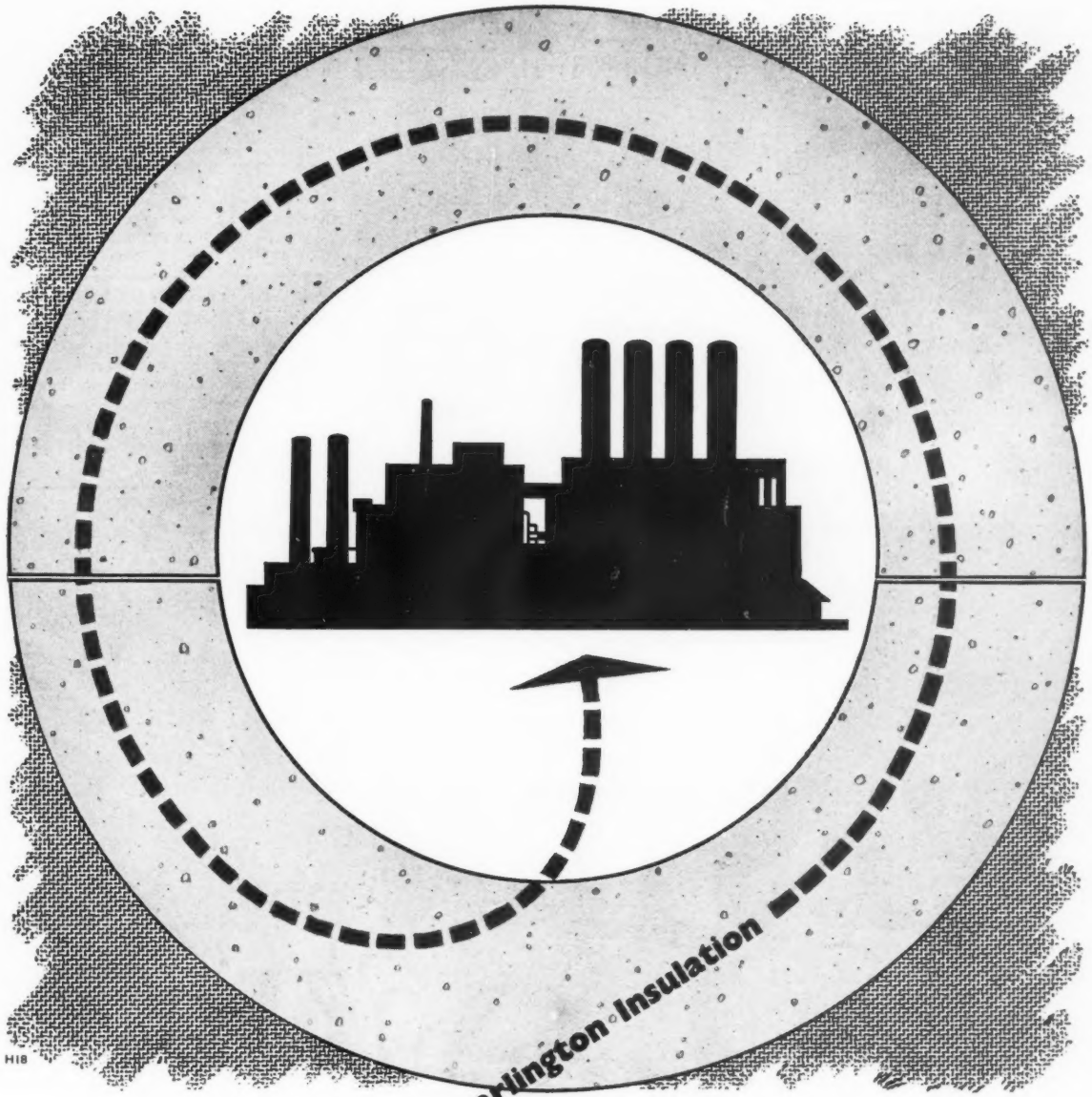

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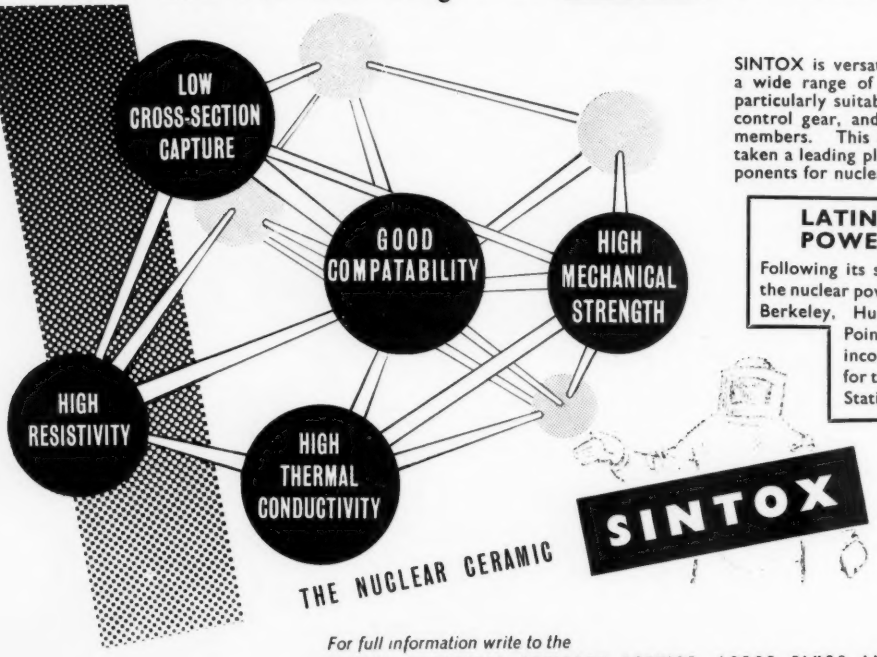

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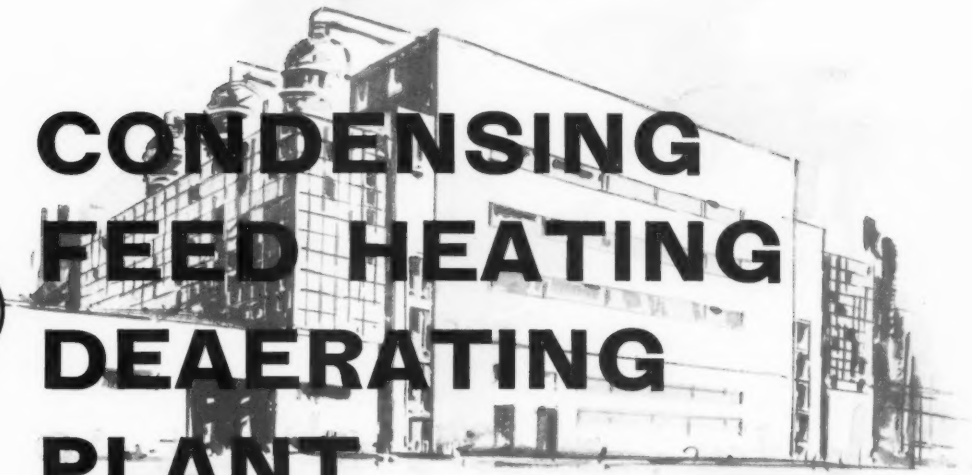

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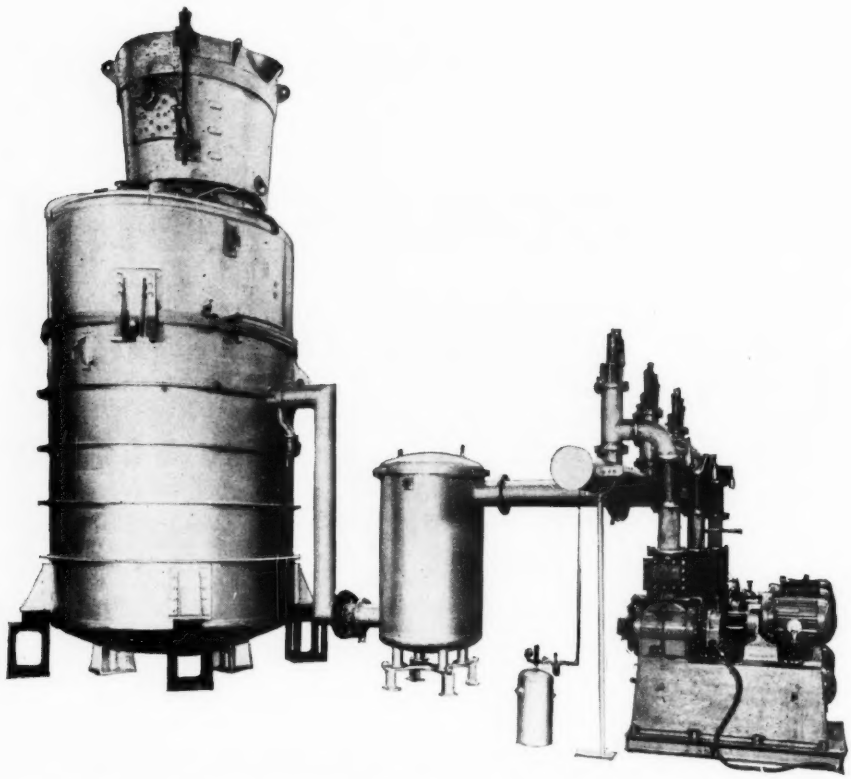

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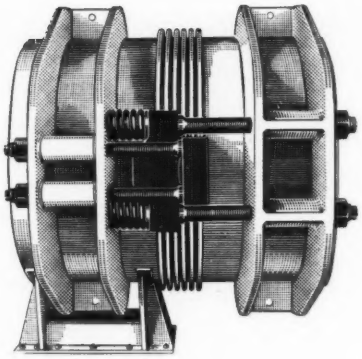

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DECEMBER, 1959

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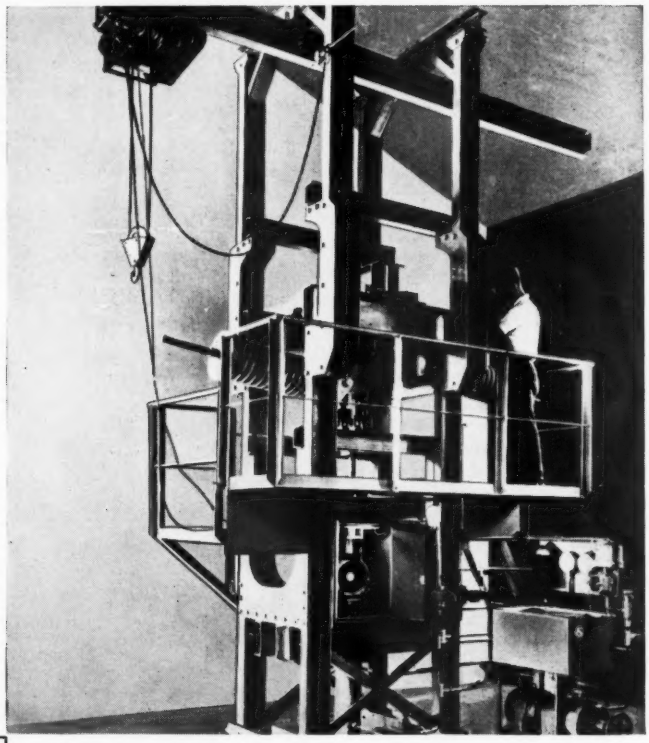

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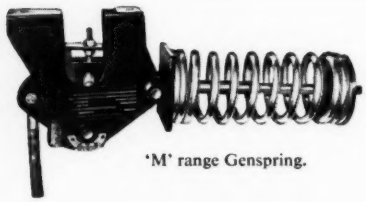

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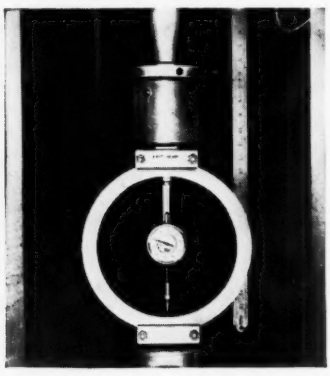

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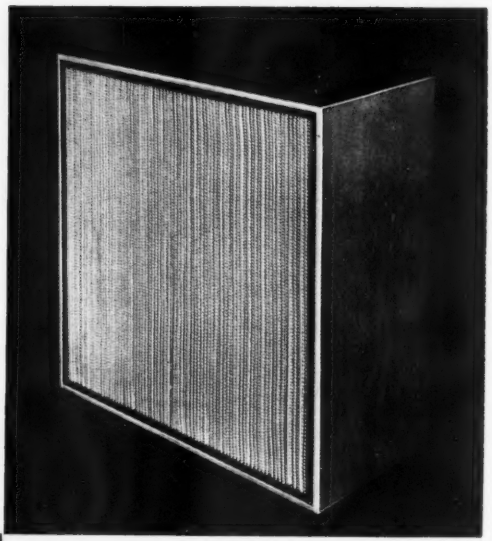

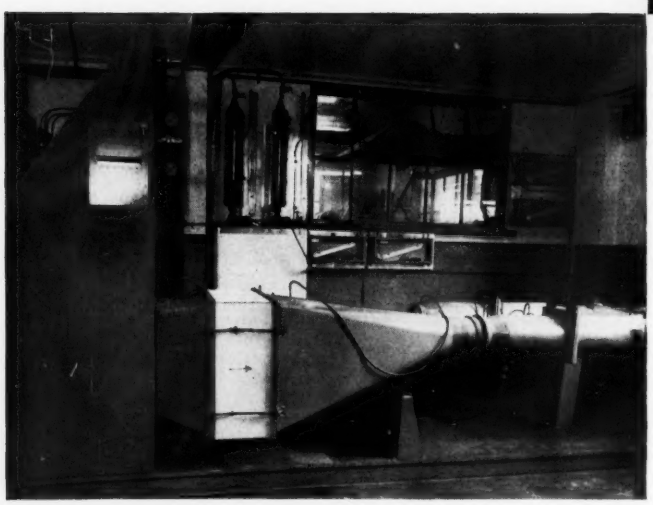

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Highlight of the inaugural meeting of the Institution of Nuclear Engineers, described in detail elsewhere in this issue, was the investiture of the newly-installed president, Sir John M. Duncanson, with the presidential jewel of office. Designed by Mr. Raphael Kochan, the jewel symbolizes the peaceful uses of nuclear energy. Against a background of gold, the torch of knowledge is surmounted by the nuclear symbol, which is in white gold, and the laurel of peace, in green enamel. The name of the Institution encircles the jewel in blue. On the reverse side are inscribed the words, "Presented by the Founder, J. B. Pinkerton, Esq., 23rd October, 1959." Our illustrations show the obverse side (on the right) *and the reverse* (below).

Presidential Jewel of Office

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Sir John M. Duncanson

SIR JOHN McLEAN DUNCANSON, born in February, 1897, started his career in the steel industry with the Steel Company of Scotland, of which he eventually became managing director. During the 1939-45 War he was appointed director of heavy steel products and then deputy controller. In 1942 he became controller, in which position he continued until the end of the war. He then became technical and commercial director of the British Iron and Steel Federation. He is now resident in London and for the past ten years has been a member of the board of the National Research and Development Corporation. He is chairman of Rhodesian Iron and Steel Co. (Pty.), Ltd., and of Metropole Industries Ltd., a director of the National Commercial Bank of Scotland, the Lancashire Steel Corporation and a number of other companies. Sir John served in World War I in the Queen's Own Royal Glasgow Yeomanry (Cavalry). One very interesting time in his life was when, after devising the allocation system for steel in this country, the United States authorities, who were in a quandry on this aspect of devising ways and means of handling their steel for war purposes, sent over a Mission to this country to study our methods. The outcome was that the Mission went back and recommended the United States Government to adopt our method, which they did. Later, Sir John headed a joint Anglo-American Mission to all the Commonwealth countries to persuade them to adopt the same steel allocation system. Sir John was honoured in 1947 by the Americans with the award of the U.S. Medal of Freedom and in 1954 by Luxembourg when he was made a Commander of the Luxembourg National Order of Oaken Crown.

VICE-PRESIDENT

Mr. D. S. Watt, BSc

D. S. WATT is managing director of Sir Joseph W. Isherwood & Co., Ltd., London and New York, Naval Architects, Consulting Engineers, and ship surveyors. In that capacity he has been closely associated with the designs of some of the largest ships afloat, notably oil tankers and ore-carriers. During the war he was at the Admiralty as a senior temporary technical assistant to the late Sir James Lithgow, Bt., Controller of Merchant Shipbuilding and Repairs, and the late Sir Amos Ayre, Director of Merchant Shipbuilding. For many years Mr. Watt was a technical journalist, specializing in shipbuilding, marine engineering and the iron and steel industries. Keenly interested in mathematics and physics (author of MATHEMATICS IS EASY and PHYSICS IS EASY), he has made a special study of the industrial applications of physical science and was early in the field, more than 30 years ago, in investigating jet propulsion.

THOMAS PRESTON EVERETT, born in May, 1909; was educated at Felsted School and Emmanuel College, Cambridge. Employed with Brown, Boveri & Co., Ltd., Baden, Switzerland, 1929 to 1932, as junior technical engineer in their turbine test and turbine design departments. Joined Richardsons Westgarth, Ltd., Hartlepool, 1932, as turbine engineer and worked successively on turbine design testing with responsibility for outside erection, commissioning, etc. Appointed manager of the Land Department, 1942, and joined the parent board of Richardsons Westgarth & Co., Ltd., in 1948. Subsequently appointed managing director of Richardsons Westgarth (Hartlepool), Ltd., and in 1958 came to London as executive engineer for the parent company in charge of atomic matters.

JUNIOR VICE-PRESIDENT
HONORARY TREASURER

T. P. Everett, BA(Cantab)

HONORARY SECRETARY

J. B. Pinkerton, MIMechE

JOHN BROWNLIE PINKERTON, MIMechE, MIHVE, MRSanI, was born at Glassford in 1903. He was educated at the Royal Technical College, Glasgow, and Glasgow University. A practising Consulting Engineer and partner in the firm of Dolby & Williamson, he has had a varied engineering career, including the posts of chief draughtsman and chief engineer. As a Consultant, he has served various Ministries and Public Authorities. Concurrent with his engineering career, he has engaged in technical journalism and is the author of numerous standard works, including QUESTIONS AND ANSWERS ON HEATING AND VENTILATING and THE HEAT PUMP.

COUNCIL MEMBERS

F. L. COOMBS was born in Worcester in 1912, where he received his primary education at St. John's Boys' School. While at the Swindon Engineering College, obtained the City and Guilds Certificates in Radio Communications and passed the

F. L. Coombs, LLB, AMIEE

graduateship examination of the Institution of Electrical Engineers. He read Law at the University of London. He was called to the Bar by the Middle Temple. In 1933, he entered the electronics industry and in 1938 was appointed chief engineer to the group of companies now known as Relay Exchanges, Ltd. In 1941 he joined the BBC in the transmitter operations department and in 1942 was appointed a specialist in transmission and lines. He joined the designs department of the Corporation in 1952, where he has been responsible for a number of inventions.

N. S. GRASSAM is a lecturer in mechanical engineering at Southampton University, where he is in charge of the nuclear programme. Under his guidance the university has made provision for the teaching of nuclear engineering to students taking the ordinary BSc(Eng) course. He joined Southampton in 1951 from the Royal Naval College, Greenwich, where he was a lecturer. Before that he was with the Admiralty Gunnery Establishment, Teddington. A graduate of London University, he was trained as a structural engineer and in his early days specialized in the study of stresses in concrete. He received his basic training in nuclear energy at the Harwell Reactor School.

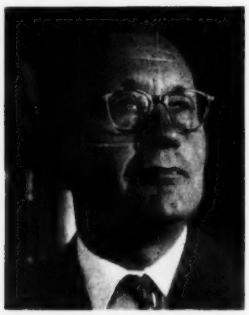
N. S. Grassam, BSc, PhD

H. F. JONES received his technical education at the Birmingham Central Technical School, the Dudley and Staffs Technical College, and the University of Birmingham, where he obtained the Diploma of Graduate Studies in Thermodynamics

H. F. Jones, AIME

and Related Studies. After war service he worked with the Rover Co., Austin Motor Co., and, later, Humber, Ltd., Coventry. After part-time consulting work with the Incandescent Heat Co., Ltd., he joined them as chief engineer, heat transfer division. After five years as a visiting lecturer, he joined the staff of the Birmingham College of Advanced Technology where he is now a senior lecturer in the department of mechanical engineering.

A. E. MERRIN was born in London in 1907; educated at Taunton School, and University College, London. Early career included six months farming in Canada and two years civil engineering on road construction. For two years (1929/30), worked in Berlin for the Swedish firm of Ruthsaccumulator AB, followed by six years as technical engineer in the paper mill machinery industry. Has been with Matthews & Yates, Ltd., 22 years, the last 16 years as technical director. Has served



A. E. Merrin, BSc

on various industrial committees and was chairman of the Unit Heater Manufacturers Association. Has been concerned with products installed at Harwell, Aldermaston. Calder Hall and other nuclear establishments.

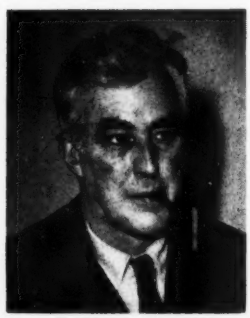
JACK MOORE is deputy head of the Research & Development Laboratories, Windscale, Development & Engineering Group of the United Kingdom Atomic Energy Authority. He joined the small team being formed in 1948 by the UKAEA, then the Department of Atomic Energy, to design the diffusion plant. In 1953, he became leader of a newly-formed group responsible for developing special plant components to operate in liquid metals and for studying the fluid dynamic properties of the Dounreay fast reactor. For the

J. Moore, BSc(Hons)

past 3½ years he has been with the Research & Development Laboratories at Windscale, where he has been responsible for experimental investigations during commissioning of the first Calder reactors and for subsequent experimental work on these reactors in aid of the civil nuclear stations and on future reactor systems.

F. R. Paulsen, BSc, PhD

FREDERICK REGINALD PAULSEN was born at Brighton in April, 1914, and took there the London BSc(Special) degree, with first-class honours, 1935. Industrial experience has embraced perfumery and cosmetics, acid production, explosives and atomic energy. On the results of development work on plastic explosives during 1939-45 war, gained FRIC in 1946. Has been head of science departments in three major technical colleges. Has inaugurated research work in technical colleges and led research teams in industry. For many years taught nuclear aspects of inorganic chemistry, and then atomic interests took him to work at Windscale Works, Sellafield, and also Harwell. As PSO, was responsible for team working on uranium, plutonium, fission products, and plant instrumentation problems. Has written widely on nuclear subjects.



H. W. B. Skinner, FRS, MA, PhD

H. W. B. SKINNER was born at Ealing in October, 1900. He was educated at Rugby School and Trinity College, Cambridge. During his eight years at Trinity he engaged in several studentships and research fellowships and worked under Lord Rutherford. Initially he worked on β-ray spectra and on excitation processes for spectra in gases at low pressures and was the first to show that light excited by an undirectioned stream of electrons is polarized. At the beginning of the 1939-45 war he joined TRE and became responsible for the first centrimetric radar equipment. He was later a member of the British team that worked on the atom bomb in America. On his return to England he joined Sir John Cockcroft in the establishment of the AERE, Harwell, and was in charge of the general physics division. In 1950 he moved to Liverpool University, where he had been appointed Lyon Jones Professor of Physics and carried on the work started by Sir James Chadwick in bringing the University's 156 in. synchro-cyclotron into operation. This project was completed in 1955 and the laboratory has since turned out a steady flow of pure research work, both at high energies using the cyclotron and in the region of a few million volts, using smaller equipment.

P. Spear

P. SPEAR was born in 1923 at Lowestoft, Suffolk; educated at Humberstone Foundation School and Sheffield University. Has been director of research of Rubery, Owen & Co., Ltd., for several years. Previously with BSA Group Research Centre running the BSA Machineability Research Laboratory. Author of various papers. In present capacity, he is concerned with many engineering scientific developments matters ranging over such a wide field as domestic equipment, Grand Prix racing cars, the automobile industry, equipment for RAF and Army, nuclear energy and so on.

For further news of the INSTITUTION of NUCLEAR ENGINEERS its aims, objects and activities . . .

Read

NUCLEAR ENERGY

every month

Mr. J. B. Pinkerton, the founder, invests Sir John M. Duncanson, the first president, with the jewel of office

THE BIRTH OF AN INSTITUTION

Sir John M. Duncanson addresses the inaugural meeting

CAXTON HALL, Westminster, famed for its weddings, was the scene of a birth on October 23rd. It was the inauguration of a new learned and professional society—the Institution of Nuclear Engineers.

Like the wedding ceremonies the occasion was brief and simple. Because of this, however, it was of no small importance or significance. Engineers and scientists working in nuclear energy fields throughout the world have long waited for an independent organization which would not only act as a forum for them to exchange, discuss and comment on their ideas, plans and problems, but which would also give them a status of their own. By the creation of the Institution of Nuclear Engineers these needs are a long way to being met.

How pressing the needs are can be judged from the fact that by the day of inauguration 538 engineers and scientists from 14 countries had intimated their interest in the formation of the Institution by returning forms of application for membership. Although there was by no stretch of the imagination anything like this number of people at the Caxton Hall meeting there were enough to suggest that there was a real and lasting interest amongst the applicants. Representatives of both industry and the universities were present and there was little doubt of their enthusiasm at being in at the birth of this enterprise.

Officers of the Institution at the inaugural meeting. (*Left to right*) **Mr. D. S. Watt, vice-president, Sir John M. Duncanson, Mr. J. B. Pinkerton, honorary secretary, and Mr. T. P. Everett, junior vice-president and honorary treasurer**

The highlight of the meeting was the installation of Sir John M. Duncanson as the Institution's first president. This consisted of the founder of the Institution, Mr. J. B. Pinkerton, ceremoniously investing Sir John with the presidential jewel of office—a handsome piece of workmanship in gold fully described and illustrated elsewhere in this issue. For Mr. Pinkerton, who originally conceived the idea of the Institution and who has been largely instrumental in its formation, it was a proud moment indeed. For Sir John, too. There could be no better acknowledgement of his skill and talents than entrusting him with the formidable and hazardous task of guiding the Institution through its first and most difficult year.

A doughty Scotsman who has served both Britain and British industry to the best of their advantage, Sir John started his term of office with words truly indicative of the spirit in which he intends to lead.

Active Future Ahead

"Gentlemen," he said, "You probably realize that the Institution of Nuclear Engineers which you have to-day seen ceremoniously inaugurated is destined to be one of action. That is, gentlemen, we intend and are dedicated to do things—not merely talk about them."

He then went on to say that he thought he was right in saying that "no Institution ever came into being with such world-wide support as the organization which you gentlemen

(*Above*) **Mr. J. D. Ward asks a question during the meeting.** (*Right*) **An informal discussion after the meeting**

have made possible. We have received application for membership from no fewer than 538 nuclear engineers spread over no fewer than 14 countries. In short, we are an international organization right from the start.

British Influence

" In saying this, we must not forget the old country," Sir John continued. " Our country has always been a leader in science, never a camp follower. A friend of mine some years ago visited the great Einstein; on the walls of his study were four portraits. On one wall was a portrait of Newton; on another one of the great Scottish physicist, James Clerk Maxwell; on another Michael Faraday, and on the fourth wall Newton again. Note, gentlemen, that these men who had inspired Einstein were all one hundred per cent. British.

" These really great Britons in fact laid the foundations of modern physics and its most far-reaching off-shoot, nuclear science. It is therefore right and proper that the technical society which will make the applications of that science its special province should be a British enterprise. Hence here we are."

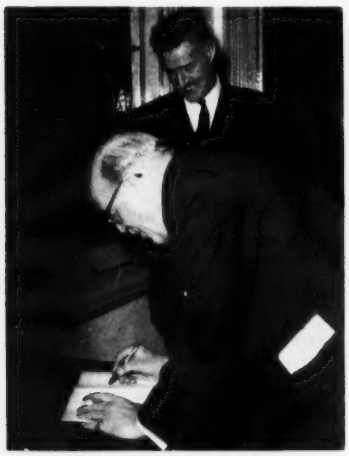
Sir John then referred to the work of the National Research and Development Corporation, of which he is a director. He pointed out that the work of this organization had greatly contributed to enhancing Britain's international reputation in science and development.

" We realize, however, that science is not the property of any one nation," the president added. " It is or should be, the servant of mankind, and it will be foremost in the aims of this Institution to make nuclear energy our servant and not our master, still less our destroyer."

" It will be the uses of nuclear energy applied to the service of man that will be our main interest, Sir John affirmed.

Two Council Members, Dr. N. S. Grassam (*left*) **of Southampton University, and Mr. J. Moore, of the UKAEA, Windscale**

Dr. F. R. Paulsen (*right*)**, Council Member, writer and technical consultant, with Mr. Tony Rea, assistant editor of** NUCLEAR ENERGY ENGINEER



Sir John Duncanson signs the visitor's book. Mr. Everett looks on

Coming down to the more immediate practical aspects of the Institution, Sir John said they were not going to spend their time talking. " I must remind you," he said, " that to-day's proceedings were necessary as a preliminary to the formality of accepting your applications for membership."

" An Enviable Honour "

He then assured the meeting that membership of the Institution would " mean something."

" We of course, want funds. Even so, we will not accept applications from those who have not the qualifications the council consider necessary. I can tell you this, that as soon

Mr. A. T. Baldock (*left*) greets Mr. H. F. Jones, Council Member and senior lecturer at the Birmingham Advanced College of Technology

Mr. M. Falk (*left*) and Mr. C. C. Bates, two of the 500 engineers and scientists who have shown interest in the Institution

as possible we hope to establish the fact that it will be an enviable honour to be a fellow or member of our organization," the president concluded.

Following the president, Mr. Pinkerton, the honorary secretary, who had previously introduced Sir John to the meeting and had announced the names of the elected members of the Institution Council, explained that the meeting, as Sir John had said, was purely a formality and that nothing definite could be announced about the constitution and organization of the Institution until the Board of Trade had approved the Articles of Association. However, if there were any questions from the audience he would do his best to answer them.

First question came from Mr. D. R. Morris. He wanted to know what would be the qualifications of membership to the Institution.

Sir John M. Duncanson discusses the aims of the Institution with Mr. Rea

Replying, Mr. Pinkerton pointed out that this would depend ultimately upon the Council. He did think, however, that very probably they would take membership of the senior Institutions or the holding of a university degree as a suitable qualification.

The honorary treasurer, Mr. Everett (*right*), with Mr. Watt

Mr. J. D. Ward urgently requested that membership of the Institution of Structural Engineers should be considered as a suitable qualification.

"This would again be a question for the Council to decide," Mr. Pinkerton answered.

With no further questions or comments coming from the floor of the meeting, Mr. T. P. Everett, junior vice-president and honorary treasurer, proposed a vote of thanks to Sir John M. Duncanson for taking on the onerous task of being president in the Institution's first year of existence. He felt sure that under Sir John's leadership the Institution would make a fine start.

Mr. Pinkerton (*right*) puts over a point to Mr. D. S. Watt

Two enthusiastic supporters of the formation of the Institution of Nuclear Engineers, Mr. C. D. O'Malley (*left*) and Mr. G. R. Clay

FIRST COUNCIL MEETING

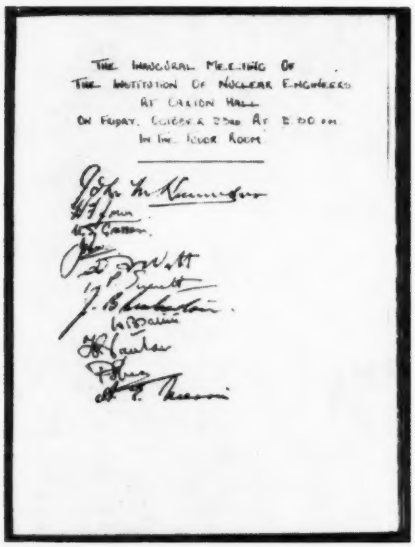
The Agenda of the first meeting of the Council of the Institution of Nuclear Engineers, held at Caxton Hall on November 16th, 1959, was as follows:—

1. Approve grades of applications for membership and elect applicants;
2. Set up Committee to deal with Education and Applications;
3. Set up Finance and General Purposes Committee;
4. Approve Articles of Association;
5. Approve probable date of first Annual Dinner, say, March, 1960;
6. Suggest guest or guests at Dinner;
7. Approve design of Membership Certificate;
8. Approve fees to be paid for all grades of membership;
9. Suggestions for Papers to be read for discussion at Meetings in January, February and March, 1960, also September, October, November and December, 1960;
10. Approve Financial Year, say, as from January, 1960 to December, 1960;
11. Suggestions for Branches, say, in Birmingham.

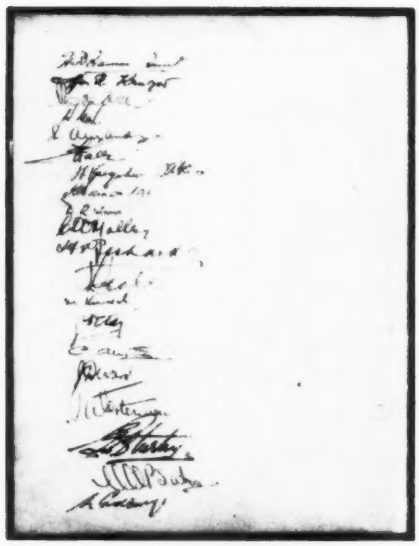
The PIONEERS . . .

The Engineers and Scientists at the Inaugural Meeting of the Institution of Nuclear Engineers

AN HISTORIC OCCASION AUTOGRAPHED


THE INAUGURAL MEETING OF
THE INSTITUTION OF NUCLEAR ENGINEERS
AT CAXTON HALL
ON FRIDAY, OCTOBER 23RD AT 5.00 PM
IN THE LESSER ROOM

From the first pages of the Visitors' Book



SIR JOHN M. DUNCANSON
MR. H. F. JONES
DR. N. S. GRASSAM
MR. J. MOORE
MR. D. S. WATT
MR. T. P. EVERETT
MR. J. B. PINKERTON
BRIGADIER W. B. SALLITT
DR. F. R. PAULSEN
MR. P. SPEAR
MR. A. E. MERRIN
MR. H. D. HAMER-HUNT
MR. M. R. KRUCZALA
MR. A. T. BALDOCK
MR. W. CODD
MR. E. ALEXANDER
MR. M. FALK
CAPTAIN H. F. ATKINS
MR. H. BAINBRIDGE
MR. D. R. MORRIS
MR. C. F. O'MALLEY
MR. H. RICHARDS
MR. F. L. VEALE
MR. M. KUSMIRAK
MR. G. R. CLAY
MR. C. AUSTIN
MR. J. D. WARD
MR. V. WESTERMAN
MR. G. W. STURLEY
MR. C. C. BATES
MR. L. GOLDWYN

MR. F. L. COOMBS was also present

MR. C. MOORE and
PROFESSOR H. W. B. SKINNER
sent messages notifying the meeting of their unavoidable absence.

DRESDEN GOES CRITICAL—Part II

U.S.A.'s First BWR Station

(*Continued from page 555*)

THE axial flux distribution in a boiling water reactor is considerably distorted by the boiling and resultant loss of moderator in the upper portion of the core. This would result in high flux peaking in the lower part of the core, except that in this reactor the control rods are admitted to the lower part of the core, reducing this peaking. Also, by adjusting the pattern of control rod insertion, the normal flux distribution is flattened. The total peaking factor, including axial peaking, radial peaking, local peaking, at 125 per cent. power, is 3.66.

The reactor core is controlled by 80 control rods. These rods are made from 2.0 per cent. boron stainless steel plate. They are cross-shaped, 6½ in. wide and 0.375 in. thick. They move between fuel assemblies and are guided by the assembly channels. A guide tube for each control rod extends upward from the bottom of the vessel to the bottom core support plate to guide the rods in this region. The control rod drive mechanism is described above.

Basic Turbine Design

The turbine is a 25-stage, 1,800 rev/min dual-admission, tandem-compound double flow machine. It is directly connected to an 1,800 rev/min, 245 kVA, 0.85 p.f., 30 lb/sq.in. gauge, hydrogen-cooled generator. The set is rated at 192,000 kW at 2½ in. Hg back pressure.

The basic design objective was to design a turbine which, despite the unusual conditions of using wet steam containing free hydrogen and oxygen, approaches as nearly as possible the reliability and freedom from maintenance expected of turbines built for currently conventional steam conditions.

Taken into Account

The overall turbine design was based on the following design precepts:—

1. The quality of the steam expanding through the turbine should be maintained within the range of successful experience by the use of suitable moisture-separating devices self-contained within the turbine;

2. Stage energy and pressure drop in the high pressure portion of the steam expansion should be less (approximately one-half) than that commonly used on modern turbines designed for conventional high pressure superheat conditions.

3. Internal wire-drawing type leakage paths ordinarily unimportant in normal steam turbine design practice should be eliminated to the greatest practical extent; and

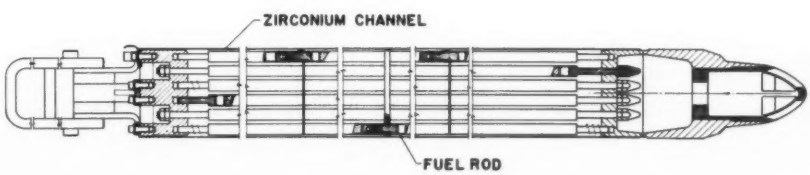
4. Where impossible to eliminate such leakage paths, the surfaces forming the leakage path should be faced with erosion-resistant materials deposited by welding. The generator and the excitation system are of conventional design.

In the event that the steam generated in the reactor exceeds the amount required by the turbine for any reason, a by-pass system is provided to dump this excess steam into the condenser. The by-pass system consists of eight valves, each of which is followed by pressure-reducing orifices and de-superheating water spray nozzles. The capacity of the system is 125 per cent. rated primary steam flow.

The valves are located on a valve chest, similar to the turbine throttle valves, and are operated by the turbine control system. After the pressure of the by-pass steam has been reduced by the valves and orifices, cold condensate is sprayed into the steam before it enters the condenser to de-superheat to saturation at a pressure of approximately 6 lb/sq.in. abs.

Leakages Accounted For

The condenser receives the exhaust steam from the turbine, steam from the by-pass system, feedwater heater vents and drains, and miscellaneous vents and drains. It is a single-pass, divided water box, with a surface area of 120,000 sq.ft. As tube sheet leakage would place an excessive load on the condensate demineralizer, double tube sheets are used. The tubes are rolled into each of the two tube sheets at either end and the spacers between the sheets are filled with demineralized water at a pressure higher than the circulating water pressure. Thus, any leakage into the vacuum space will be demineralized water rather than river water. In order to reduce the carry-over of short-lived radioactive substances (principally N16) into the feedwater system, the deaerating condenser hotwell is so sized and equipped with baffles that all condensate is retained in the hotwell a minimum of three minutes.



Fuel assembly for use in the Dresden reactor. There are 488 of these in the core and each one is made up of 36 fuel rods consisting of Zircaloy-2 tubing and enriched dioxide pellets

Condenser auxiliaries are conventional except that the steam air ejector has greater flow capacity to remove the hydrogen and oxygen resulting from dissociation of water in the reactor as well as normal air leakage.

Pumping Equipment

There are two sets of feedwater pumps, one set of primary pumps supplying the reactor and one set of secondary pumps supplying the steam generators. There are three pumps in a set, each providing one-half the total requirements. The pumps are directly driven by electric motors and are of conventional construction. They are located in the cycle before the feedwater heaters, taking suction from the condenser hotwell condensate pumps.

The plant has three water treatment systems to supply and maintain high purity reactor system water. Maintaining high purity of the water in the reactor system is essential in order to prevent accumulation of radioactive particles or corrosion products in the reactor system and in the turbine-condenser-feedwater system. Accumulation of radioactive substances in equipment or piping would present a maintenance problem.

All contaminated liquids produced in the plant are processed in a special waste disposal system. The functions of this are to:—

1. Remove radioisotope impurities;

2. Assure radioisotopic and chemical purity of the liquids before re-use in the process or release to the river; and

3. Store in a safe manner the contaminated resins, filter materials and concentrated salt solutions.

Effluent Disposal

Wastes are held in receivers and are handled in batches. Wastes with short-lived radioactive impurities can be held up for radioactivity decay before being dumped into the river or re-used in the plant. Wastes with dissolved impurities or suspended particulate matter can be purified by a demineralizer and a high efficiency filter. Acid wastes are neutralized in a neutralizer tank. Wastes with a high impurity content are concentrated in an evaporator and the concentrate stored in underground tankage. Demineralizer resins too radioactive to be regenerated and radioactive filter materials are sluiced with water to an underground resin storage tank. The excess liquid from this tank is pumped back to the waste disposal system.

Solids contaminated with radioactive material such as laboratory wastes, contaminated clothing, waste rags, and paper from contaminated areas, and unsalvageable equipment, are collected in a shelter adjacent to the liquid waste disposal building until there is a sufficient quantity to form a bale or fill a large container. The waste is then transferred to an underground vault for storage.

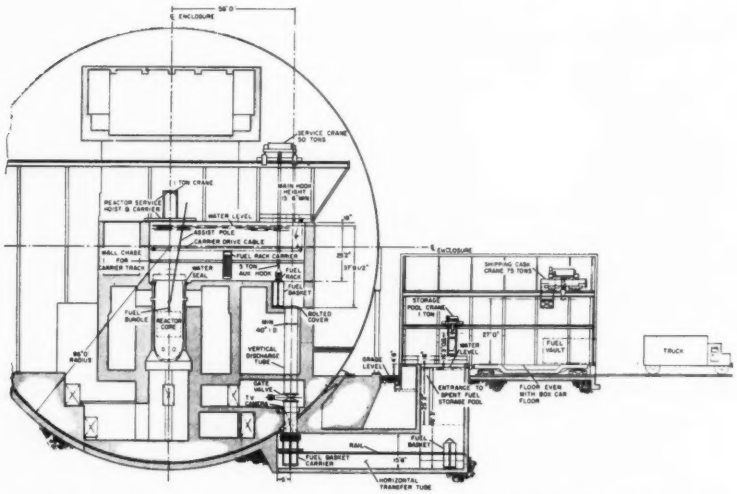


Diagram to show the fuel handling arrangements. The main features are: 1—a refuelling canal above the reactor vessel; 2—a vertical discharge tube leading from the canal; 3—a horizontal transfer tube; 4—a fuel handling pool; and 5—a fuel storage pond

Wastes in Exhaust

The ventilation exhaust contains trace quantities of dusts, mists and vapours of process origin. Similar sources originate from ventilation hoods in the radiochemical laboratory, laundry, and regulated maintenance shop. Total exhaust air flow to the 300 ft stack is expected to be about 45,000 cu.ft/min during normal operation.

A portion of the reactor enclosure air is exposed to neutron activation around the reactor vessel, with the principal activation product being argon-41, with a formation rate of 100 μc/sec.

Non-condensable gases in the steam system are removed by the air ejector on the main condenser.

The Dresden fuel handling system consists of:—

1. A refuelling canal above the reactor vessel which is flooded with water during refuelling;

2. A vertical discharge tube leading from the canal through the bottom of the reactor enclosure;

3. A horizontal transfer tube leading from the discharge tube into the fuel building;

4. A fuel handling pool in the fuel building; and

5. A fuel storage pool in the fuel building.

Spent fuel assemblies are removed from the reactor by a small crane and are transported under water in the canal to a basket. The basket is lowered through the discharge tube to a basket carrier in the transfer tube. The basket carrier is hauled to the fuel handling pool where the assemblies are removed and placed in the storage pool until they are shipped from the plant in shipping casks.

Handling the Fuel

New fuel is stored in a vault in the fuel handling building. During refuelling, the new fuel is placed in the basket carrier in the fuel handling pool and follows the reverse route to the reactor.

A lock in the discharge tube maintains water levels in the canal and in the fuel handling pool. Most fuel handling tools are hand-operated, and the operators handle the fuel visually, being protected by the water above the fuel in the canal and in the fuel handling and storage pools.

The plant is provided with a comprehensive ventilation system to protect plant personnel from airborne radioactive contamination and to provide working areas with safe temperature conditions. Air is always moved from an area of little or no potential contamination to one of higher potential contamination. Face velocities are maintained across openings into potentially contaminated areas such as will prevent escape of airborne particles or vapours. Cooling or heating coils are used where necessary to adjust the air temperature.

Operation Centre

Nerve centre of the plant is the control room. This contains all controls, indications, and records needed by the operator for start-up, shutdown and safe operation of the plant. A combination of benchboard operating consoles and vertical panels are used.

The room is shielded from all process equipment and is tenable in the event of difficulty in any part of the process system. No process lines are connected directly to the control room instruments since process liquids and gases are measured with remotely located detectors and transmitted by electrical or pneumatic signals to the control room. While most control functions are initiated in the control room, operators may perform some functions at remotely operated panels or valve racks.

Two basic mechanisms control power in the dual cycle boiling water reactor: rod control and void control.

Control Procedure

The method of controlling the reactor for start-up, normal shutdown and scramming (rapid shutdown) is with control rods. The rods consist of poison sections which may be raised into the core to decrease reactivity or lowered out of the core to increase it. The rods are controlled manually and no more than one rod can be withdrawn at a time. For scram, all rods are automatically driven into the reactor simultaneously by hydraulic means. As a back-up protection for shutting down the reactor, a manually-controlled liquid poison injection system is provided.

During normal operation, the reactor will respond to " void " control which depends on varying the water moderator density. As the volume of steam voids within the reactor is varied, the effective density of the water moderator is altered, and the total reactivity decreased with an increase in the steam-void volume. The excess reactivity allowed by the control rod setting is balanced by the negative void reactivity. The core boiling boundary will vary with sub-cooling as will the core-exit steam quality. However, the net reactivity worth of the steam-void accumulation, regardless of its distribution, is unchanged for a given control rod setting.

Control of the plant is carried out by means of a speed governor and an initial pressure regulator mounted on the turbine. These two controls are tied together by a special control linkage system to operate the primary turbine admission valves, the primary steam by-pass valves, and the secondary turbine admission valves. The pressure regulator holds essentially constant pressure in the reactor vessel to prevent reactivity changes arising from pressure fluctuation. Primary steam is admitted to the turbine in a sufficient quantity to hold the set pressure. If the turbine cannot accommodate the required steam flow, the by-pass valves are opened and excess steam is dumped into the condenser.

Following Load Demand

The turbine speed governor controls secondary steam to the turbine. Secondary steam flow controls the reactor inlet water sub-cooling.

As the electrical demand is increased, more secondary steam is admitted to the turbine, sub-cooling at the core inlet is increased, and boiling occurs at a higher level in the core. The reduced void accumulation increases core power and primary steam generation. Void reactivity also returns to a value equivalent to that before the load change (assuming the control rods are not moved). By this means, load control in the range of about 40 per cent. to 100 per cent. of full load is obtained automatically by changes in secondary steam flow, obviating the need for control-rod repositioning. Larger load changes will require repositioning of the control rods.

In the design of the Dresden station the principal safeguard objectives aimed for are:—

1. Normal operation of the plant must not result in the exposure of

Areas of Improvement

The boiling water reactor system shows promise of considerable improvement over the Dresden design described in this article. Some of the areas of potential improvement are as follows:—

Nuclear Superheat: The boiling water reactor has the potential of being able to provide superheated steam. This will give a substantially better heat rate and will permit the use of more conventional steam turbine design. With the progress which is being made in fuel element development, nuclear superheat in boiling reactors should be possible in the not too distant future.

Higher Steam Pressure: In conjunction with nuclear superheat, higher pressures would lead to improved heat rates and lower power costs. However, as long as saturated steam is used, there is little incentive to go to higher pressures. The gain in heat rate does not justify the increased equipment costs.

Supercritical Pressure and Temperatures: It is entirely possible that the boiling water reactor could eventually evolve into a single-pass steam generator operating in the supercritical region.

Reactor Specific Power: With more boiling water reactor operation experience and improved fuel element design, it is very probable that substantially higher specific power could be achieved with the Dresden-type reactor core. Higher specific power would result in more power output for a given size reactor system and would substantially reduce plant first cost.

Larger Plant Size: Boiling water reactor power plants considerably larger than Dresden could be built, especially when higher specific power is achieved. This would reduce plant cost per installed unit of capacity.

Different Cycles: Boiling water reactor power cycles different from Dresden, such as cycles using natural circulation and internal steam separation, are under investigation and may prove to be more economical.

Enclosure Substitute: It is possible that a lower cost method of reactor system containment than the Dresden-type reactor enclosure might be developed.

Plutonium Recycle: It is probable that a boiling water reactor power plant could be made independent of enriched uranium supply by the plutonium recycle method. It is also possible that plutonium recycle may lead to lower fuel costs.

any persons on or off the plant premises to radiation in excess of the permissible limits; and

2. Safety against a nuclear accident that might release dangerous amounts of radioactive materials must be preserved even in the event of equipment malfunction, operator error, or other reasonable contingencies.

Restricting Radioactivity

The approach toward meeting the first of these objectives has been to develop a system design in which there is very little radioactive material to be routinely released to unrestricted areas, and to locate or shield sources of radiation inherent in the systems to the extent necessary to minimize personnel exposure during the performance of normal operating tasks in the power plant.

The principal radiation from which plant personnel must be shielded are neutron radiation leaving the reactor during operation, fission-product-decay, gamma radiation from the nuclear fuel, and the energetic (6 MeV) gamma radiation of the nitrogen-16 created by neutron bombardment of the reactor cooling water. Other sources of radiation include oxygen-19, neutron captive activation products of reactor materials, and corrosion products from the entire system.

The dose rates used in determining the shielding requirements vary according to the plant area under consideration and the expected occupancy of the area. A summary of the general design criteria is tabulated below:—

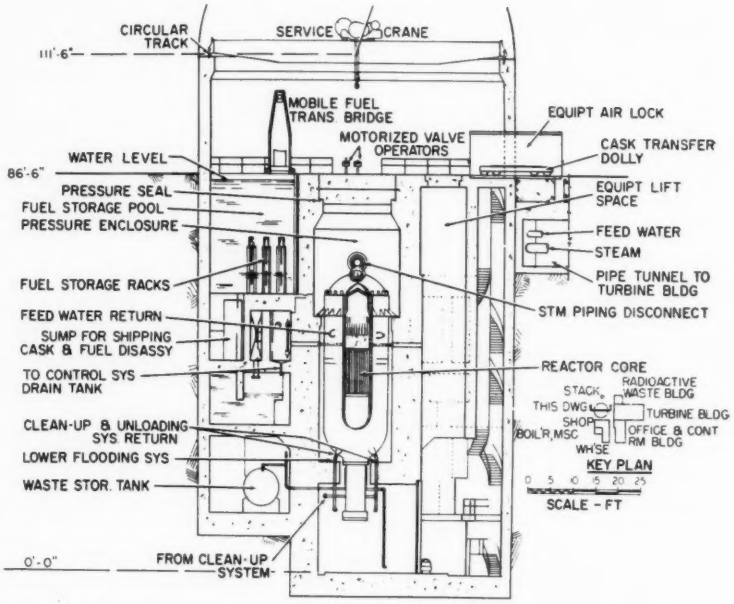
Area	*Expected occupancy*	*Design level*
Uncontrolled ..	Continuous	$<\frac{1}{2}$ mr/hr
Radiation zone	Substantial	1 mr/hr
Radiation zone	5-10 hr/week	6 mr/hr
Radiation zone	$<$5 hr/week	12 mr/hr

The shielding material used throughout the plant consists of ordinary concrete.

The approach to meeting the second of these objectives has been to:—

1. Choose a reactor design that will tend to shut itself down upon a potentially dangerous increase in its power.

2. Provide two separate and independent systems to shut the reactor down.



Drawing to show possible internal arrangement of a 200 MW advanced boiling water reactor

3. Provide two separate and independent systems for cooling the reactor.

4. Provide multiple safety sensing devices to detect and/or prevent any potentially unsafe operating condition from becoming too severe.

5. Design safety devices in such a way that their malfunction would shut the reactor down rather than cause or permit an increase in its power.

6. Design control of the reactor and primary equipment to minimize the possibility of an operator error that could lead to an unsafe operating condition.

Although the possibility of a nuclear accident is extremely remote, by virtue of the provisions indicated above, the reactor and associated equipment will be housed in an air-tight enclosure to confine radioactive arisings that might be liberated from a reactor rupture accident and so prevent extensive radioactive contamination of the environment.

The provisions of specific features to minimize the possibility of nuclear accidents are based on comprehensive analysis and evaluation of the general types of contingencies that have a reasonable possibility of occurrence.

The major electrical equipment and systems of this plant will consist of a generator, transformer, high voltage switchyard, auxiliary power system, emergency power systems, and associated station services. The net electrical output of the plant will be 180,000 kW. Energy will be generated at 14.4 kV and will be stepped up by means of a single three-phase main power transformer to the transmission voltage of 138 kV. This power will be channelled through the high voltage switchyard to the transmission lines feeding the Commonwealth Edison system.

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25 GeV

PROTON SYNCHROTRON AT GENEVA GOES INTO OPERATION

The European Organization for Nuclear Research (CERN) recently announced the completion at Meyrin, near Geneva, Switzerland, of its 25 GeV proton synchrotron. It is currently the world's largest completed accelerator. Brookhaven National Laboratory's 30 GeV proton synchrotron is scheduled for completion by early next year. A start has not yet been made on the 45 GeV linear accelerator planned for Stanford. The largest machine announced so far is the 50 GeV proton synchro-phasotron to be built at Leningrad, Russia. The Meyrin accelerator is the second to be built there for the CERN. The first is a 600 MeV synchrotron-cyclotron which came into operation in August, 1957.

(*Above*) **Interior of the ring building before the installation of the magnets. It is in here that the particles are accelerated up to 25 GeV. Circumference of the ring is about ¼ mile.** (*Left*) **Part of the main proton synchrotron laboratory during the construction stage. In middle background can be seen an electric hoist used for the handling of the barytes concrete shielding blocks.** (*Below*) **Close-up of this hoist. The barytes blocks provide a 16 ft to 17 ft thick protection against radiation**

CERN—the initials are from the French *Conseil Europeen pour la Recherche Nucléaire*—is an international organization established for joint research in nuclear physics. It was set up in 1954 following the recommendations of an intergovernmental conference organized by UNESCO in 1952. The intervening years were spent by a provisional organization in formulating detailed technical plans and draft budgets.

Twelve countries belong to CERN. They are Belgium, Denmark, France, the Federal Republic of Germany, Greece, Italy, Netherlands, Norway, Sweden, Switzerland, the United Kingdom, and Yugoslavia. They contribute financially to the organization on a percentage basis. The largest annual contribution is made by the United Kingdom, who take account for a quarter of the annual budget. Other large contributors are France, Germany and Italy.

The staff working at the CERN laboratories at Meyrin near Geneva, on a site offered by the Swiss Government, are recruited from all the member countries. About 600 scientists, technicians and others are engaged on projects there.

Most of the work at Meyrin is related to the two giant accelerators, the 600 MeV synchro-cyclotron that came into operation in 1957, and the 25 GeV proton synchrotron. Experimental work with the latter machine is expected to start in 1960.

Other activities at Meyrin relate to the development of new experimental techniques.

THE DISPOSAL OF RADIOACTIVE WASTES INTO COASTAL WATERS*

by

H. J. DUNSTER,

UKAEA Industrial Group

Part II—Assessment of Results

(*Continued from page 543*)

AT intervals during the period since the beginning of discharges, reviews have been made of the implications of the results and the work has, therefore, been divided into a series of somewhat arbitrary experimental periods. In presenting the results it has been found convenient to retain this division into experimental periods.

The first period, covering the year 1952 and the first quarter of 1953, was used to assess the spread of radioactivity in the marine environment and to find out how soon an equilibrium would be reached. The results showed that equilibrium conditions were achieved after discharges lasting for only a few months and this has been confirmed by the later experience. This short time can be explained by presuming a fairly rapid transfer of activity out of the immediate environment. It is of considerable interest that this process affects activity on the sea bed as well as that in seaweed and fish.

Safe Discharge

The subsequent periods, numbered 2 to 6, range from nine to 15 months and cover the period up to the end of 1957. A preliminary report on the results of period 2, up to April 1954, was made by Fair and McLean[1] at the 1955 Geneva Conference, and these results were used as the basis for a complete re-assessment of the permissible discharges. This re-assessment showed that discharges of nearly 1,000 curies/day of beta activity and of a few curies/day of alpha activity would be safe provided that additional restrictions were put on the discharges of ruthenium-106 and strontium-90.

More Radioactivity

Periods 3 and 4 were used to confirm these conclusions and in 1956 the rate of discharge of radioactivity was deliberately increased, partly to dispose of unwanted wastes, but principally to yield better experimental data. These results have not made it necessary to modify the maximum permissible discharges adopted at the 1954 assessment.

Table II shows the details of the experimental periods and the amounts of the various materials discharged. This is followed by Tables III to VII, which show the numbers of samples analysed and the arithmetic mean of the results in each period. These tables show that the levels of ruthenium and total beta activity in seaweed, the limiting factors in these discharges, have been systematically

Table II.—Experimental Periods and Amounts Discharged

Period Number	2	3	4	5	6
Dates	6/4/53 25/4/54	25/4/54 25/6/55	26/6/55 4/3/56	4/3/56 31/3/57	31/3/57 5/1/58
Duration (Months of 28 days)	14	15	9	14	10
Mean Discharges (curies/28 days)					
Total alpha	1.25	1.53	12.33	4.89	4.61
Total beta	1,350	2,011	1,326	6,572	4,549
Ruthenium-106	364	709	247	3,280	1,483
Total beta excluding Ru106	986	1,302	1,079	3,292	3,066
Strontium-90	74	33	27	147	143

Table III.—Radioactivity of Shore Sand

Type of activity	Period	Number of samples	Mean activity (μμc/g dry weight)	M.p.l. (μμc/g dry weight)
Total beta	2	40	24	
	3	38	24	
	4	30	36	25,000
	5	46	74	
	6	25	57	

*Paper presented at the 2nd International Conference on the Peaceful Uses of Atomic Energy, Geneva, 1958.

Table IV.—Radioactivity of Shore Silt

Type of activity	Period	Number of samples	Mean activity (μμc/g dry weight)	M.p.l. (μμc/g dry weight)
Total beta	2	5	5,880	
	3	9	3,510	
	4	4	4,080	100,000
	5	50	11,980	
	6	33	5,930	

Table V.—Radioactivity of Sea Bed

Type of activity	Period	Number of samples	Mean activity (μμc/g dry weight)	M.p.l. (μμc/g dry weight)
Total beta	2	103	1,260	
	3	195	580	
	4	113	690	100,000
	5	249	4,030	
	6	64	4,790	
Ruthenium-106	5	88	2,525	
	6	24	4,249	100,000

below the maximum permissible levels. In all other cases, the activity levels in marine materials have been below about 10 per cent. of the maximum permissible levels.

In addition to the main sampling programme, occasional surveys have been made at distances extending up to about 50 km from the outlet. At this distance the activity levels do not differ significantly from the natural background levels.

To Find Safe Limits

The aim of the sampling programme has not been solely to demonstrate the safety of the discharges, although that has been a necessary part of the operation. Equally important has been the estimate of the maximum amount of radioactivity which can be discharged with complete safety into the coastal water off Cumberland. This estimate has been made by taking a weighted mean of the results from each period for the levels of the various activities in seaweed, the limiting material. This weighted mean has then been divided by the overall mean rate of discharge to give the activity level expected from a discharge rate of one curie/28 days. When this number is divided into the appropriate maximum permissible level, the estimated permissible rate of discharge is obtained.

This process is shown in Table VIII.

The only weighting factor used has been the length of the period. The ease, and probably the accuracy of the analysis increases as the rate of discharge of activity increases, but the general uncertainties in sampling procedures in this type of work outweigh any such increase and it was not felt that it would be justified to give any weight to the discharge rate.

Seaweed Interferes

One sampling error is known to exist and is caused by a preponderance of seaweed samples from the region of the coast near to the discharge point. A correction factor of 1.5 has been used to reduce this error and is incorporated into the final estimate of the activity resulting from a discharge rate of one curie/28 days. To simplify the comparison between periods, Table VIII also includes the values of the mean activity resulting

Table VI.—Radioactivity in Fillets of Plaice (*Pleuronectes Platessa*)

Type of activity	Period	Number of samples	Mean activity (μμc/g wet weight)	M.p.l. (μμc/g wet weight)
Total alpha	3	26	0.020	
	4	28	0.008	30
	5	42	0.012	
	6	13	0 048	
Total beta	3	26	3.6	
	4	28	4.2	2,000
	5	42	9.1	
	6	13	7.0	
Ruthenium-106	3	26	0.80	
	4	29	0.71	1,000
	5	42	2.35	
	6	11	2 25	
Total beta excluding ruthenium-106	3	26	2.0	
	4	28	2 8	2,000
	5	42	4.4	
	6	11	2 5	
Strontium-90 (*a*) (*b*)	3	26	0.06	
	4	29	0 05	
	5	42	0.05	8
	6	11	0.06	

Notes (*a*) All these results are close to the threshold of detection.

(*b*) All the results for strontium-90 include a small contribution from strontium-89.

from a discharge rate of one curie/28 days for each period separately. These values have not been adjusted by the factor of 1.5.

Not Final Figures

The figures shown in Table VIII for the maximum permissible discharges are the best that can be made at present, but they cannot yet be regarded as final. In any case they cannot be applied in practice without consideration of possible additive effects of concurrent discharges of different isotopes. In particular, strontium and the alpha emitters are bone seekers and must be regarded as additive, while both ruthenium and the majority of the other beta emitters have to be limited because of the dose they deliver to the lower part of the gastro-intestinal tract and must, therefore, be treated as another additive group.

The difficulties of assessing both the magnitude and the maximum permissible levels of total beta activity necessitate the inclusion of safety factors which cannot yet be properly evaluated. These factors, combined with the effect of dilution of the Cumberland seaweed by weed supplied from other areas, mean that the maximum permissible discharges have been under-estimated by a factor which is unlikely to be less than three.

The work reported here has been entirely concerned with studies of the discharges off the Cumberland coast, but it can, in part, be applied to problems in other coastal areas. The limiting factors in coastal disposal will usually be local peculiarities and it is, therefore, helpful to summarize the peculiarities of the coastal environments of Windscale.

Limiting Factors

No regular currents, but a good tidal stream parallel to the coast.

Considerable turbulence, giving good vertical mixing and dispersion by eddy diffusion.

Considerable suspension of fine particles.

No shell fish used for human food.

Local fish are bottom feeders, remaining for some time in the local area, but not completely static.

Edible seaweed commercially harvested on the shore.

Sands used by holiday-makers.

Table VII.—Radioactivity in Edible Seaweed (*Porphyra Umbilicalis*)

Type of activity	Period	Number of samples	Mean activity (μμc/g wet weight)	M.p.l. (μμc/g wet weight)
Total alpha	2	36	0.11	
	3	117	0.14	
	4	45	0.33	10
	5	257	0.27	
	6	131	0.22	
Total beta	2	40	92	
	3	145	96	
	4	91	96	670
	5	256	260	
	6	130	226	
Ruthenium-106	2	55	22	
	3	68	44	
	4	33	40	330
	5	162	120	
	6	52	181	
Total beta excluding ruthenium-106	2	40	48	
	3	62	22	
	4	33	40	670
	5	159	60	
	6	—	—(*a*)	
Strontium 90 (*b*)	2	17	0.23	
	3	48	0.03	
	4	36	0.07	2.7
	5	57	0.21	
	6	9	0.04	

Note:—(*a*) The uncertainty in interpretation of the results for this period is too great to allow them to be used. (See page 543).

(*b*) All the results for strontium-90 include a small contribution from strontium-89.

Apart from the edible seaweed and the lack of any regular currents, most of these features tend to encourage the good dispersal of radioactivity and to reduce its reconcentration in materials which are of interest to man.

In assessing the disposal problems at any site in relation to the experience gained at Windscale it is convenient to start from the effects of a unit discharge of one curie/month (28 days) from Windscale. Table IX shows the weighted mean results obtained from the earlier tables, with the addition of the mean results of some 70 analyses of the flesh of mussels, *Mytilus sp.*, from a few kilometres from the Windscale discharge point.

Useful for Other Coasts

The table also shows the relevant maximum permissible activity levels and the fraction of these permissible levels that results from a continued discharge of one curie/month. With appropriate local adjustments to the values in columns 2 and 3, Table IX can be used to make a preliminary estimate of the safe discharge rate into other coastal environments. The accuracy of such estimates will depend very much on the degree of similarity of the environment to that at Windscale and on the extent to which it proves possible to make quantitative comparisons of such variables as the degree of dispersion, the uptake by different species of fish and seaweed, and man's use and consumption of marine products.

Dounreay and Winfrith

In addition to the Cumberland coast two other areas in the United Kingdom have been the subject of investigations aimed at assessing their suitability for radioactive waste disposal. These have been the north coast of Scotland, near Thurso, where the Dounreay Experimental Reactor Establishment is sited, and the south coast of England, near

Weymouth, which is close to the new research establishment at Winfrith Heath. At both these sites lobsters are of commercial importance but they are otherwise completely different. The coast near Dounreay is rocky and the water is generally clear apart from the presence of finely ground shells in suspension near the shore. The shore in Weymouth bay is sandy and the water consequently carries a heavy suspension of particles.

Slower Dispersal

Preliminary work at Dounreay has shown that the dispersion of activity, at least in the region within a few hundred metres of the shore, is less rapid than at Windscale, partly because of the presence of underwater rock barriers parallel to the shore. A further problem is set by the existence in rough weather of a stable spume which is blown inshore in considerable quantities and carries with it some of the fine particles in suspension near the shore. For these reasons, the permissible discharges were estimated as the result of an experimental series of discharges of fission product solutions from a temporary pipeline near the shore.

Supplementary experiments with a fluorescent dye were used to study the movement and dispersion of water in the region of the proposed final pipeline. These studies have shown that discharges of about one-tenth of those possible at Windscale would be completely safe, but that further work, involving prolonged discharges, will be necessary to establish with accuracy the maximum permissible discharge rate.

"Operation Mermaid"

The experiments off the South Coast were designed first to find the best point from which to make the discharges of liquid waste which will eventually arise from Winfrith Heath, and secondly to study the processes affecting dispersion of effluent in this area. The work has been done with a fluorescent dye released from a ship and is similar to that reported previously at Geneva by Seligman[2]. The rates of diffusion have been found to be at least as rapid as those occurring off Windscale, but the situation is complicated by a tendency for the tidal stream to set inshore for much of its flow.

The considerable lobster fishing industry, with the resultant handling of gear which spends long periods on the sea bed also introduces factors which are absent at Windscale. Up to the present no radioactivity has been discharged in this area and only a preliminary assessment has been possible. It is estimated that the maximum permissible discharges will be about the same as those at Windscale, but until this has been confirmed by a series of experimental discharges, the radioactivity in the effluent will be restricted to one-tenth of the estimated safe figures.

The results of preliminary hydrographic and biological studies, followed by extensive monitoring of the marine environment during about five years of discharges of radioactivity at a mean rate of about 3,000 curies/month, have shown the following general pattern of dispersal of activity in the sea off Cumberland.

Plaice Take Up Activity

The length of the pipeline is such that the concentration of deposited beta activity on the shore sand is about 50 times lower than that on the sea bed near the effluent outlet. The fish in this area, of which plaice are the most important, live on the sea bed and consequently take up activity from the water, from the particles, and from the invertebrates which form their food.

Table VIII.—Weighted mean Activities in Seaweed for a Unit Discharge Rate and Maximum Permissible Discharges

Type of activity	Period	Mean activity for a discharge rate of 1 curie/28 days (μμc/g)	M.p.l. in seaweed and associated maximum permissible discharge rate
Total alpha	2	8.8×10^{-2}	
	3	9.2×10^{-2}	
	4	2.7×10^{-1}	10 μμc/g
	5	5.5×10^{-2}	
	6	4.8×10^{-2}	
Weighted mean (*a*)	All periods	3.1×10^{-2}	320 c/28 days
Total beta	2	6.8×10^{-2}	
	3	4.8×10^{-2}	
	4	7.2×10^{-2}	670 μμc/g
	5	4.0×10^{-2}	
	6	5.0×10^{-2}	
Weighted mean (*a*)	All periods	3.2×10^{-2}	21,000 c/28 days
Ruthenium-106	2	6.0×10^{-2}	
	3	6.2×10^{-2}	
	4	16.2×10^{-2}	30 μμc/g
	5	3.7×10^{-2}	
	6	12.2×10^{-2}	
Weighted mean (*a*)	All periods	4.1×10^{-2}	8,000 c/28 days
Total beta excluding Ru106	2	4.9×10^{-2}	
	3	1.7×10^{-2}	
	4	3.7×10^{-2}	670 μμc/g
	5	1.8×10^{-2}	
	6	—	
Weighted mean (*a*)	All periods	1.7×10^{-2}	39,000 c/28 days
Strontium-90	2	31.1×10^{-4}	
	3	9.1×10^{-4}	
	4	25.9×10^{-4}	2.7 μμc/g
	5	14.3×10^{-4}	
	6	2.8×10^{-4}	
Weighted mean (*a*)	All periods	9.7×10^{-4}	2,800 c/28 days

Note:—(*a*) Adjusted for non-uniform distribution of sampling (see page 589).

The discharged effluent is rapidly diluted with large volumes of sea water and is carried to and fro along the coast over a distance of a few kilometres by the oscillating tidal stream. Beyond the range of this movement, the activity is removed by the process of eddy diffusion and the concentration falls to negligible levels in a few tens of kilometres. Much of the radioactivity becomes adsorbed on to fine particles of sand, mud, and organic matter in suspension and some of this is deposited on to the sea bed.

Seaweed Uptake

The activity level in the edible parts of fish is many hundred times less than that in the sea bed and is probably not greatly different from that of the surrounding water. Some of the activity reaching the shore is absorbed not by the sand but by seaweed, and as this weed is used almost directly as a food, stringent limits have had to be placed on its activity.

Most of the weed harvested in Cumberland grows within about 20 km of the effluent outlet and there is no substantial dilution by weed from other areas. Consequently maximum permissible discharges are limited primarily by the activity of this weed and by the need to safeguard the small group of people who regularly eat it in quantity.

Overall Conclusions

The results of this experimental programme have shown that it would be safe to release some 20,000 curies/month of fission products at a point about 3 km off this part of the Cumberland coast. Further work now in hand suggests that this figure could reasonably be increased, possibly to as much as 100,000 curies/month. These high figures are possible because the marine processes in this area cause sufficient dispersal to prevent any continuing build-up from year to year in the activity levels either in the vicinity of the outlet or in the more widespread regions of the Irish Sea.

Similar discharges of radioactivity are possible in other coastal waters but the safe discharge rates can be determined only by local experiments. Although hydrographic and laboratory studies are of great help in the preliminary assessment of the safe discharge rate, the greatest value must be attached to scientifically planned experimental discharges of radioactivity lasting for a period of at least a few months. These experiments should be continued during the first few years of operational discharges to investigate long period variations and the possibility of a continuing build-up of activity. Thereafter, a much reduced monitoring programme will probably serve to ensure that the conditions remain safe.

Such an experimental programme represents a considerable scientific effort and the Windscale programme, covering a period of nearly 11 years, has involved a team varying between about ten and 20 technical staff. It is hoped that the experience gained at Windscale Works as a result of this extended experiment will make it possible to simplify the experiments needed to establish safe discharge rates at other coastal sites.

Table IX.—Summary of results of Discharges from Windscale

Type of activity and of sample	Weighted mean activity for a discharge rate of 1 curie/28 days (μμc/g)	M.p.l. (μμc/g)	Fraction of M.p.l. resulting from discharge rate of 1 curie/28 days
Total alpha			
Seaweed	3.1×10^{-2}	10	3.1×10^{-3}
Fish	4.1×10^{-3}	30	1.4×10^{-4}
Mussels	3.1×10^{-1}	30(*a*)	1.0×10^{-2}
Total beta			
Seaweed	3.2×10^{-2}	670	4.8×10^{-5}
Fish	1.6×10^{-3}	2,000	8.0×10^{-7}
Mussels	8.2×10^{-2}	2,000(*a*)	4.1×10^{-5}
Shore sand	1.3×10^{-2}	25,000	5.2×10^{-7}
Shore silt	2.0	100,000	2.0×10^{-5}
Sea bed	6.9×10^{-1}	100,000	6.9×10^{-6}
Ruthenium-106			
Seaweed	4.1×10^{-2}	330	1.2×10^{-4}
Fish	1.0×10^{-3}	1,000	1.0×10^{-6}
Mussels	3.0×10^{-2}	1,000(*a*)	3.0×10^{-5}
Shore silt	1.1	100,000	1.1×10^{-5}
Sea bed	1.3	100,000	1.3×10^{-5}
*Total beta excluding Ru*106			
Seaweed	1.7×10^{-2}	670	2.5×10^{-5}
Fish	1.3×10^{-3}	2,000	6.5×10^{-7}
Strontium-90			
Seaweed	9.7×10^{-4}	2.7	3.6×10^{-4}
Fish	6.3×10^{-4}	8	7.9×10^{-5}

Note:—(*a*) Same figure taken as for fish although off this coast mussels are not used for food.

References

[1]FAIR, D. R., and MCLEAN, A. S., "The discharge of radioactive waste products into the Irish Sea, Part III." Paper P.420, Geneva, 1955.

[2]SELIGMAN, H., "The discharge of radioactive waste products into the Irish Sea, Part I." International Conference on Peaceful Uses of Atomic Energy, Vol. IX. Paper P.418, Geneva, 1955.

The work of which the results are reported here has been the responsibility of several groups. The preliminary hydrographic work was arranged by the Atomic Energy Research Establishment at Harwell, and the subsequent assessments were made by the Research and Development Branch, Windscale, who were also responsible for the early part of the experimental programme and for much of the laboratory work on fish and seaweed. The studies of fish movement and landings and of seaweed harvesting and consumption, as well as the rest of the laboratory work on fish, have been carried out by the Fisheries Laboratory of the Ministry of Agriculture, Fisheries and Food. The Health Physics Department of Windscale Works has been responsible both for the general planning of the experimental discharges and for the sampling programmes. The analytical services for the monitoring programme have been provided by the Chemical Services Department of Windscale Works.

The author is grateful to all these bodies, to the individual workers within them, who provided the data on which this report is based, and to Mr. J. C. Collins who has co-ordinated the many thousands of individual results which have been summarized in the Tables.

WANTAGE Industrial Irradiation Facilities

Commercial Applications

Interior of one of the 23 cobalt-60 experimental radiation cells at the Wantage Irradiation laboratories of the UKAEA

SOON, hospitals and clinics throughout the British Isles will be using a range of medical equipment and accessories that have been treated to a new and promising form of sterilization—nuclear radiation. Already, catheters, at the rate of 10,000 a week, are being treated in this way. When the United Kingdom Atomic Energy Authority's continuously-operating cobalt-60 bulk irradiation processing plant at Wantage shortly comes into operation they will be joined by similarly-sterilized products, such as cotton wool and expendable plastic hypodermic syringes.

The installation of the irradiation facility at Wantage, although essentially a pilot plant, represents a major landmark in the work of the Authority in this field. It is said to be the largest plant of its kind and size in the world and it will be used for the first large-scale continuous application of gamma radiation for an industrial process in this country.

Dual Purpose Tool

Radiation can be used in two ways —either as a tool of investigation, measurement and testing, or as a direct agent for inducing physico-chemical processes. In the first type of application the radiation source is small; in the second it needs to be large.

Radiation as a checking tool has already found many applications in industry—indeed, it would be difficult to find an industry which does not use it in this way. As a processing agent, however, it has been used outside the laboratory only either for medical purposes or for an industrial purpose on a very limited uneconomical scale. The irradiation of inert materials, such as packaged medical products, at present seems to be the only industrial process application with the likelihood of a commercial future. The first commercially-operated irradiated plant is, in fact, now being built in Australia. It will be used for sterilizing animal fibres against anthrax.

Group Work

The plant being built at Wantage, which is due to be completed by the end of this year, will be operated by the Technological Irradiation Group of the Atomic Energy Authority. Established in 1955 from an offshoot of the Isotopes Division, this group was formed specifically for studying, designing and developing ways of using large radiation sources for industrial and biochemical purposes. Its investigations to date have covered sterilization, polymerization, food preservation, insect control and extermination, plant genetics, catalystic actions and the production of pharmaceuticals.

Sterilization by irradiation is the first application under investigation that has been taken beyond the laboratory stage on any sizable scale. At present results are encouraging. Hospitals using the irradiated catheters, for instance, have reported a considerable drop in the number of infections to the urinary tract in cases where catheters are used. The Group, however, are anxious to make it plain that it is too early to say whether these results are entirely due to the new form of sterilization. They could well be due to "human factors." Medical staff might well take extra care in using these catheters, knowing that they are irradiated.

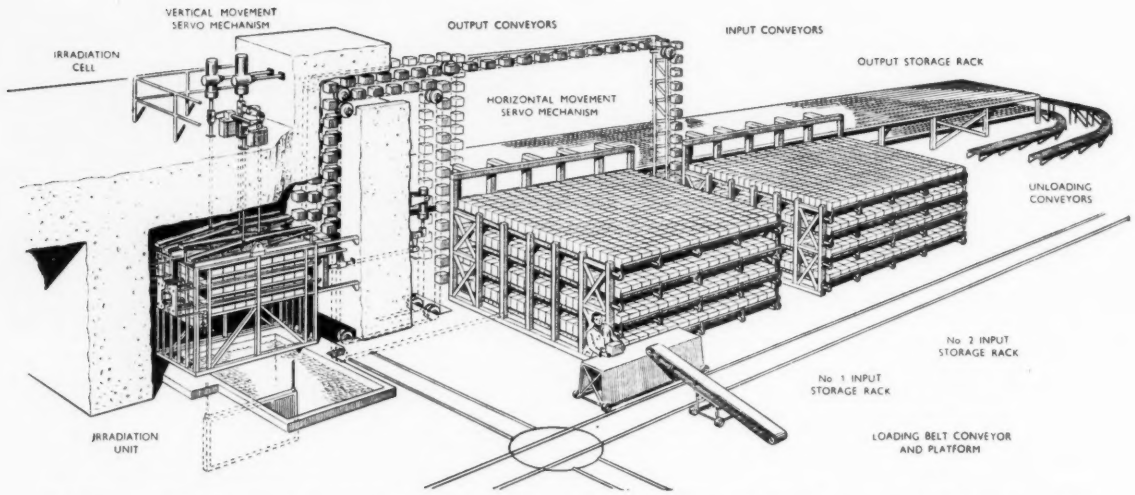
There are two types of irradiation sources suited for industrial work—radioactive materials such as Co60 and Cs137, and machines which accelerate nuclear particles to very high energies. The Group believe the former type has the greater potentiality.

Of the two radioisotopes best suited for industrial irradiation Co60 is currently the cheapest and most readily available. It is produced by irradiating Co59 with neutrons.

Producing Co60 Pencils

The ordinary cobalt or Co59 is made up into $\frac{1}{4}$ in. pencils encased in stainless steel. After being tested for leaks, the pencils are grouped together and inserted into cans which are placed inside a reactor. After irradiation the cans are opened up and the pencils individually tested and measured for radioactivity. According to their activity the pencils are grouped together again and sealed into the source tubes. Following argon welding and leakage tests, these are ready for use.

Cs137 is a by-product of nuclear fission and a special processing plant is required for its recovery. The



Cut-away drawing of the irradiation processing plant under construction at Wantage. The irradiation source, initially to be 150,000 curies of cobalt-60, will be housed in the concrete cell seen on the left. When not in use the source will be stored in water under the cell

Authority is building a separation plant at Windscale which is designed to produce about 1,500,000 curies of caesium a year starting from 1960. It is hoped that this will be followed by another plant with a capacity 10 to 100 times as great. Once caesium separation is carried out on this scale it is expected to become the cheapest form of radiation source.

The preparation of caesium for canning into source tubes at present involves technical difficulties which add to the total cost. It is expected that before caesium becomes readily available these will have been overcome.

At present the Group is working principally with Co60. Facilities at Wantage, where the Group occupies a former airfield, include 23 experimental cells using Co60 with strengths ranging from 200 to 4,500 curies. The irradiation facility under construction will also use Co60. It is designed to take strengths of up to 500,000 curies, but initially will be loaded with 150,000 curies.

Spent Fuel Pond

There is also a 4 MeV linear accelerator chiefly used for producing the larger doses needed in radiation chemistry. In addition, the Group operates a spent fuel element pond at Harwell. This is used for irradiating materials by exposing them to fuel elements taken from the high flux reactors DIDO and PLUTO. The catheters are sterilized here.

The facility basically consists of a 20 ft deep water pond. Fuel elements are discharged to the bottom through a special funnel designed to prevent the spread of radioactivity. There they are sheared at both ends by special cutting machinery and inserted into open-top containers. These are then moved to the irradiation area into which materials to be irradiated are lowered.

The catheters, wrapped in double polyethylene bags, are packed in cardboard cylindrical containers. These are placed into metal containers, two at a time, one on top of another, which are then sealed and lowered into the pond to stand between the fuel elements. Exposure time is just over one hour. At half time the containers are raised and the cardboard boxes changed in position to ensure that the catheters are evenly irradiated.

Three Tons a Day

While this method is suitable for small quantities of material it would be quite unsatisfactory for continuous bulk irradiation for which, of course, the irradiation processing facility is designed. With a 150,000 curie source it will be possible to sterilize materials in this plant at the rate of 7 megarad-tons a day. Taking $2\frac{1}{2}$ rads as being the necessary sterilizing dose, this means the daily throughput of, say, medical products or animal fibres would be three tons.

The plant occupies an area of about 10,000 sq.ft. This includes storage space for materials both before and after processing, all the mechanical handling plant and the irradiation cell itself. The latter occupies about 1,000 sq.ft, including the massive concrete shielding walls.

The plant is so designed that material will be passing through the cell all the time, and packages will be handled automatically. Because it is a pilot plant there are some refinements and additions which would not be necessary on a purely commercial plant. There are, for instance, two storage and loading systems and a speed range ratio of 400:1. At top speed a package will take six minutes to travel through the cell, at the minimum speed, 40 hours.

Cubic Foot Packages

The plant is based on a unit package size of approximately 1 cu.ft. The medical products that will be among the first items to pass through the plant will be packed in cardboard boxes of approximately this size. These will take about nine hours to travel through the cell.

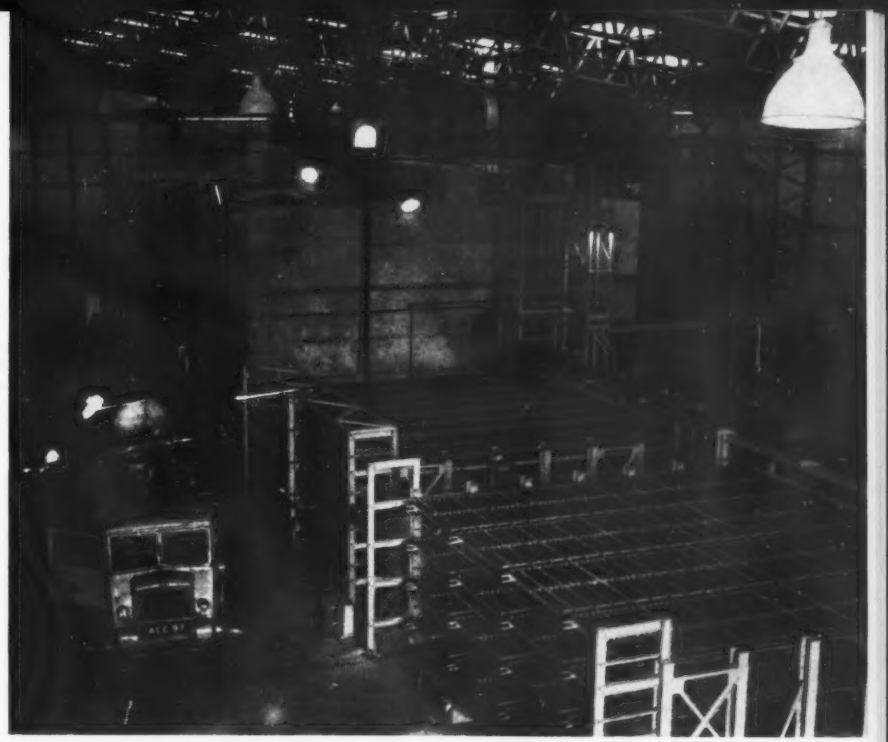
There are two conveyor systems through the cell, an inner and an outer. The idea of this is to ensure that the maximum amount of radiation emitted from the source is used. Material passing along the inner system will not always absorb all the radiation given off by the source. A second outer system enables this surplus to be used. The systems are operated independently so enabling them to be run at different speeds.

Inside the cell each package passes the length of the source 10 times, five with one side exposed and five with the other. This is made possible by

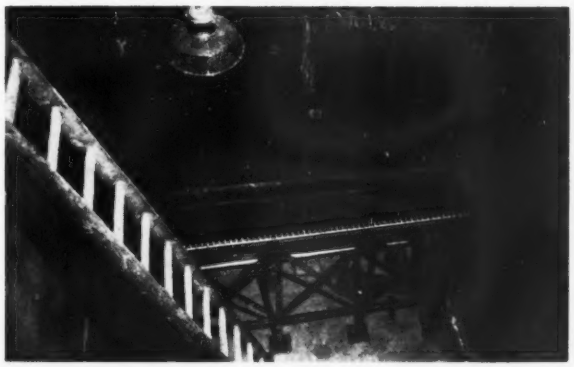
a special arrangement of conveyors and lifts and it ensures that the packages are evenly irradiated.

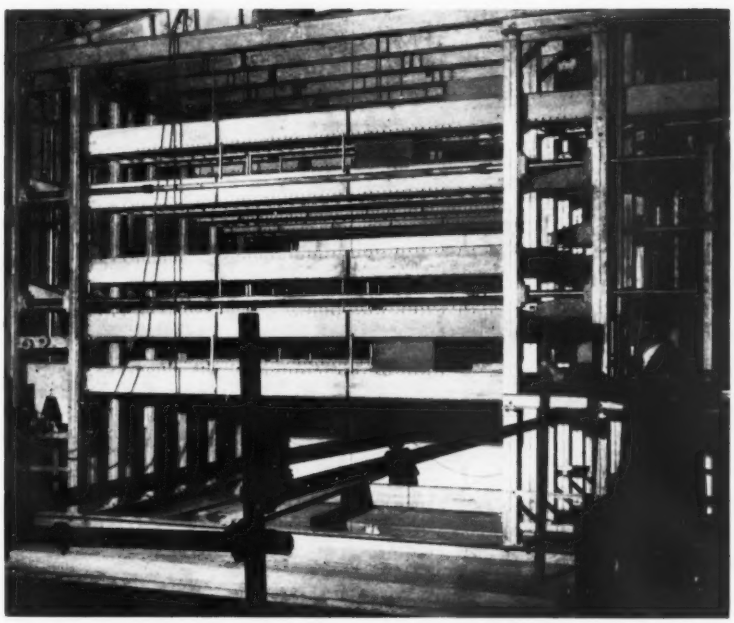
Carefully-designed interlocks and control devices are incorporated throughout the plant to ensure correct radiation dosage and to prevent any health hazards. When the plant is not in operation the source is stored in a special pool of water under the irradiation storage cell.

The contract for the detailed design and construction of the handling and storage equipment of the pilot plant has been left in the hands of the Owen Organization. The



(*Right*) **General view of the irradiation facility under construction at Wantage. Two irradiation cells have been built. The second cell will be used in future developments.** (*Below*) **The source storage pit. It will be filled with water when the plant is in operation**





(*Left*) **Inside the irradiation cell showing the conveyor and lift system by which boxes to be irradiated pass the length of the source 10 times, five on one side and five on the other.** (*Above*) **The space in the centre of the conveyor system for the radiation source**

main companies concerned with the project are the parent company, Rubery, Owen & Co., Ltd., of Darlaston, and Electro-Hydraulics, Ltd., of Warrington. Other companies of the Group will also contribute.

The general design of the plant was carried out by the Engineering Division of the Atomic Energy Research Establishment, Harwell, to the specifications of the Technological Irradiation Group.

RADIATION DAMAGE

Report from British Association Meeting

by

C. S. GRACE, MSc, DIC

One of the sessions at the recent annual meeting of the British Association for the Advancement of Science was devoted to different aspects of radiation damage. The keen interest which at present prevails on this topic resulted in the session being well attended, and in addition to physicists a number of members of the engineering, physiology and biochemistry sections were present. The four lectures which were delivered ranged widely over this rapidly growing subject, giving the audience an insight into some of the important problems which currently confront metallurgists, physicists, chemists, and biologists. Mr. Grace, who delivered one of the lectures, reports on the session.

THE first lecture, entitled " Radiation Damage and Atomic Displacements in Crystals," was delivered by Dr. W. M. Lomer, who heads the Theoretical Physics Division at the Atomic Energy Research Establishment, Harwell. Dr. Lomer explained the importance of minimizing radiation damage if nuclear power reactors are to be made competitive with conventional means of power generation. The damage problem in a reactor can be subdivided into three groups of effects:—

(*a*) damage to the moderator,

(*b*) damage to the fuel elements,

(*c*) damage to the structural and containing materials such as steel supports, which may undergo alterations in ductility, hardness or creep.

" Since these problems are specific to an environment with a heavy neutron flux " said Dr. Lomer " money spent on high flux materials testing reactors may result in substantial economies in the construction and operating costs of future power reactors."

But fundamental research is also needed if the problems which arise when a new fuel such as plutonium is introduced are to be overcome.

If graphite at 50°C. is irradiated with fast neutrons and subsequently heated to 100°C., the temperature of the graphite will rise of its own accord to about 300°C. This " self-heating " is a consequence of the displacements produced by the irradiation of the atoms in the graphite lattice. The laws of mechanics show that a 1 MeV neutron colliding with a carbon atom will impart an energy of about 0.1 MeV to the latter. The recoil of the struck atom causes the displacement of many other atoms, resulting in the production of vacant sites and interstitial atoms. These are in a state of higher potential energy than the normal atoms in the lattice, and would release this energy immediately but for the fact that they are " jammed in " by neighbouring atoms.

Windscale Recalled

The return of the displaced atoms is an activated process which is temperature dependent, the rate of return therefore being given by

$$\text{rate} = Ae^{-k/T}$$

where A and k are constants and T is the absolute temperature. After the Windscale accident a thorough investigation of the mechanism of the energy release was initiated. By measuring the rate of release of the stored energy from irradiated graphite at different temperatures the constants in the relation given above were determined. Thus the rate of release of energy from graphite during operation of a reactor could be predicted with certainty. But this did not indicate how the rate of build-up of defects in the graphite varied with temperature during irradiation, and so could give little information which would help in the design of new reactors with higher working temperatures. However, further experiment has shown that the constant k in the release rate equation is not truly constant, but is a function of the amount of energy stored in the graphite. More precise data now being accumulated should enable the nature of the several processes to be completely elucidated.

Uranium fuel elements in a reactor are damaged by two main processes. Firstly, the fuel may suffer atomic displacements caused by neutrons or by fission fragments. Secondly, and more seriously, 10 per cent. of the fission fragments are radioactive species of krypton and xenon, which only exist in the gaseous phase at ordinary temperatures. The gases accumulate in small bubbles, the growth of which gives the uranium a spongy texture, and so causes " growth " of the fuel element. Electron micrographs show that the bubbles are uneven in distribution and size. Bubbles with radius less than about 10^{-5} centimetres cause little trouble since surface tension forces inhibit their growth. It is those of larger size that present a problem.

High Purity Aim

A partial alleviation of the difficulty may be achieved by ensuring that the uranium is of high purity and of fine grain. The fuel elements will then be comparatively free of large pores so that bubbles cannot develop. Dr. Lomer predicted that future trends would probably be toward the use of ceramic fuel elements, composed of either uranium carbide or uranium oxide. Once the essential fundamental work on these materials had been done the way would be clear to find the solution to present difficulties.

The second lecture was prepared by Professor A. Charlesby, Professor of Physics at the Royal Military College of Science, Shrivenham, and myself. The subject of our lecture, was " Effects of Atomic Radiation on Molecular Structure." In it we said that in recent years public interest in nuclear matters had been concentrated on two principal aspects, namely power production by reactors and the application of radioactive isotopes. There was however a third aspect—the use of high energy radiation to promote chemical as distinct from nuclear changes in materials.

" Though this is less well known at present " we said, " it has nevertheless been claimed that it may eventually be the one which makes the greatest impact on our lives." The radiation-induced chemical changes may result in a deterioration of the properties of a material, a factor of great importance to the reactor engineer. Conversely, the changes may lead to the production of modified or entirely new materials with most useful properties. Already some materials are being produced commercially be this means, and others will become practicable propositions when the cost of radiation falls to a lower level.

Ionization Important

Although high energy radiation may interact in several ways with the material through which it passes, in organic materials only one effect is of importance—the ionization or excitation of binding electrons in the organic molecules. As a consequence of this the molecules decompose into reactive fragments or radicals which readily recombine to form different chemical molecules, perhaps with new properties. If the radiation is restricted to electrons or gamma rays with energy not higher than a few MeV, nuclear changes leading to induced radioactivity of the material are completely avoided and only the chemical changes occur.

Bearing in mind that about 30 MeV of energy is required to ionize a molecule, it follows that a particle or quantum of 1 MeV energy can ionize about 30,000 molecules, and so modify on average one chemical bond in each. For a material of molecular weight 100 this corresponds to a radiation dose of about 1.6×10^9 roentgens, or 3m. times the lethal dose to man; the most powerful types of radiation sources would take about half an hour to administer such a dose. But if the material has a molecular weight of 100,000 then the dose required to modify one bond per molecule is only 1.6m. roentgens. This is readily achieved. It is therefore seen that a given radiation dose is much more likely to produce appreciable changes in materials with large molecules, such as high polymers, than in low molecular weight materials.

Sometimes Deleterious

The changes are sometimes deleterious. For example, ordinary lubricating oils solidify after irradiation in a reactor. At present an intense investigation is going on to find the best organic substance for use as a moderator and coolant in reactors—to be suitable a material must resist all changes of the type being considered. Some polymers such as perspex lose their strength entirely after a few days in a reactor, and crumble away to a powder. In this case the radiation causes degradation, which is fracture of the main polymer chains, resulting in a decrease in molecular weight and loss of mechanical strength.

Other polymers have their properties improved by radiation, however, due to a mechanism termed " crosslinking." This consists of the production of direct chemical bonds between neighbouring molecules. Ultimately all the molecules lose their individual identity and become tied together into an infinite three-dimensional network. Normal polyethylene, for example, has excellent electrical properties but suffers from the disadvantage that it begins to soften below 100°C., and melts to a liquid not far above this temperature. When crosslinked by radiation, however, it no longer becomes liquid at its usual melting point but becomes rubber-like, retaining useful mechanical strength to 200°C. or higher, where thermal decomposition sets in. Polyethylene modified by radiation is already being produced for special purposes—wider application is limited only by the present high cost of radiation.

Graft Polymerization

Another instance of a useful change is the production of graft copolymers, which are materials with a backbone of one type of polymer, but having side chains of a different polymer grafted on to the backbone. Such materials, which can be produced in several ways by radiation, often show some of the virtues of each ingredient, so that a whole new range of materials with desirable combinations of properties can be built up.

Radiation-induced reactions have in addition, a considerable theoretical interest, for not only do they occur in the solid state, but they also shed light on some problems of energy transfer. Studies on polymers, some of which are not unlike large biological molecules, may assist in the interpretation of radiation effects in the complex systems of living cells.

Our paper concluded by saying that although present radiation sources, such as electrical machines operating at a few million electron volts or radioisotope units already provided intense radiation beams, the high installation or operating costs were restricting the full exploitation of radiation-induced changes. However, cheaper radiation from spent reactor fuel rods or separated fission products, seemed bound to come, and should result in enhanced scientific and commercial interest in this field.

Radiation Hazards

The third paper in the session was jointly prepared by Professor W. V. Mayneord, Professor of Physics of the British Post-Graduate Medical Federation, and Dr. R. C. Turner and Dr. J. M. Radley, both from the Department of Physics at the Institute of Cancer Research. The paper, read by Dr. Turner was entitled " Origin and Metabolism of Radioactive Materials in the Human Body."

Radiation hazards are far from being a new problem, since our environment has always been radioactive. To determine the nature of the hazard at the present time a programme was undertaken with the object of discovering what proportion of the body's radioactive intake was of natural origin, and identifying the radioactive elements concerned. On account of the low levels of activity involved such measurements have only recently become practicable, with the advent of improved counting equipment and techniques. Since the naturally occurring radioelements of

the uranium and thorium series include several alpha-particle emitters, whereas the principal constituents of fallout, strontium-90 and caesium-137, emit beta and gamma rays only, the contribution from natural sources could be assessed by using a scintillation technique to count alpha particles only. The ashed specimens were made up into thin sources and placed in contact with a phosphor sensitive to alpha particles. A photomultiplier recorded the number of particles emitted. By this mean alpha activities as low as $0.03\mu\mu$C/g. (micro-microcuries/gm) could be measured, and the responsible element determined by pulse height observations.

Independent of Age

The study was divided into three parts. Firstly, the average content of natural radioactive materials of different parts of the body was found. This showed that the concentration was quite independent of the age of the individual, the total body burden averaging between 120 and 150 micro-microcuries. Of this total three-quarters was in the bones and the rest in the soft tissues. Notably high concentrations were found in the hair and lungs, perhaps due to direct deposition of material from the atmosphere. The high activity found in the thyroid could be explained by the tendency of this gland to concentrate barium, which acts as a carrier for radium. The evidence leads to the conclusion that radioactive substances do not steadily accumulate in the body with age; instead an equilibrium appears to become established between concentration in the bloodstream from food and concentration in the bones and soft tissues. Should strontium behave in the same way, it may be that the dangers from fallout have been overestimated in the past.

Body Reactions

The second phase of the experiments consisted of the monitoring of the quantity of radioactivity eaten in food and excreted by a three year old child over a period of one month. The results were rather surprising—only 20 per cent. of the radioactivity eaten was retained in the body, the balance being excreted within 48 hr. Further, variations greater than 20 to one in the daily intake were found, depending on the diet. Hence, if 80 per cent. of the radium, which is a bone-seeking substance, is excreted by a growing child, it is improbable that the whole of the intake of Sr90 from fallout is retained in the body. Arguments based on the latter premise may therefore be groundless.

Finally, the natural radioactivity of a wide variety of goods was measured. Results obtained were startling. The activities were found to vary over a range of more than 20,000 to one, the highest by far being in brazil nuts. These contained about $1,700\mu\mu$C/100 gm, so that 4 oz of brazil nuts would contain three times the total body burden of radioactivity. The large amounts of radium and thorium in the nuts apparently arises from the way trace elements, especially barium, concentrate in them, and act as carriers for the radioactive elements.

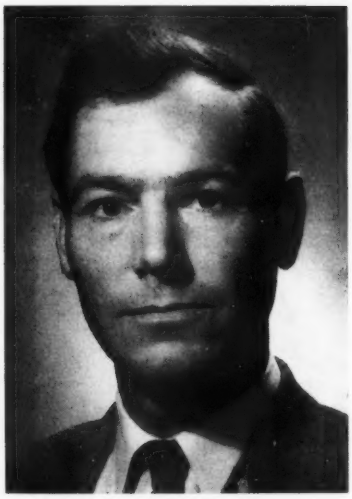
Other activities measured ranged from 60 for cereals and 1 for meat down to $0.1\mu\mu$C/100gm or less for fruit and vegetables. Thus it is possible for members of the same family to show wide variations in their daily intakes of radioactivity, but an average diet contains activity from natural sources which is 300 times the intake of Sr90 from fallout. Hence Dr. Turner's conclusion that " if the present level of Sr90 in food in this country represents a radiation hazard—and apparently it does to the armchair calculators—then the whole process of eating food must be regarded as highly dangerous."

Greater Menaces

Additional points revealed by Dr. Turner were that an anti-nausea preparation for pregnant women contains 50,000 times as much radioactivity as the normal daily intake of Sr90. Gas mantles are also a much greater menace than fallout, since one milligram of dust from a mantle contains a quantity of thorium which is equivalent to the total body burden of radioactivity.

The feature of great scientific interest which emerges from this study is how it comes about that variations from person to person in radioactive body burden are very much less than variations in radioactive content of different types of diet. It is also surprising that man manages to keep his body burden so low, bearing in mind the large daily intake. In this he is more successful than the animals; mountain sheep, for instance, may have a concentration of radioactivity in their bodies which is 200 times that of man.

This is probably accounted for by diet. Radioactivity tends to concentrate in leaves of plants, so that grazing animals accumulate considerable quantities. Fortunately the radioactivity is mainly deposited in the bones of the animal rather than the meat or milk, with consequent advantages to man, whose diet is often based on milk and meat.



C. S. Grace, MSc, DIC

Mr. Grace, who has compiled this report, is senior lecturer at the Royal Military College of Science, Shrivenham, near Swindon. He was educated at the University of Otago, New Zealand. From 1949 to 1955 he served in the Royal New Zealand Navy. During this period he was seconded for two years to the Admiralty's Underwater Countermeasures and Weapons Establishment at Havant, and from 1953 to 1955 was in charge of the Naval Research Laboratory in Auckland, New Zealand. After leaving the Navy he spent two years on electronic development work with a Survey firm, and in 1957 joined the staff of the Royal Military College of Science

Environmental Doses

The fourth lecture, delivered by Professor F. W. Spiers, Professor of Medical Physics at the University of Leeds, was entitled " Ionizing Radiation in the Environment." Professor Spiers pointed out that since little was known about the effects of the very small radiation doses which all human beings receive from various natural and artificial sources, it was important to keep a close watch on doses. Particular regard had to be

paid to any increases due to fallout, and variations from place to place.

Roughly speaking, the total dose received arises from three main sources. Cosmic rays contribute about one-quarter of the total, another quarter comes from the body's burden of radioactivity and the remainder from the environment. The amount received from the environment can show large variations, since granite rocks are much more radioactive than sedimentary rocks, and are about 10,000 times as active as fresh water.

Yearly Body Doses

In the course of a year the total dose received by the body from cosmic rays is about 25 milliroentgens at sea level in middle latitudes. This figure applies to a person who spends a good proportion of his time indoors, and so is shielded from the soft component of the rays. The total dose from the body's natural radioactive burden arises from several elements. The most important, potassium-40, contributes 21 milliroentgens per year. Although the activity of the body's content of carbon-14 is about half that of K40, the low disintegration energy of the carbon results in a dose from this source of only 1.6 milliroentgens/year. Finally, radium and radon together add a further 1.5 milliroentgens/year, making a total from the body burden of about 24 milliroentgens/year. A typical value for the radiation received from the environment is 50 milliroentgens/year, making a total from all three sources of about 100 milliroentgens.

Regional Variations

Experiment, however, shows that the contribution from the environment can vary widely. For instance, the value in a street or inside a granite house in Aberdeen is 105 milliroentgens/year, whereas, in Edinburgh it would not exceed 50 milliroentgens. An area in India is known where the radioactivity of the rocks and soil is such that the environmental dose is more than ten times the normal figure. These three sources, giving a total dose of 100 milliroentgens/year, constitute the normal and unchanging background radiation to which man has always been exposed.

The present population of the earth is subject to a number of additional sources of radiation due to the activities of man. X-ray examinations for example add on the average 22 milliroentgens/year. Recently, as a result of nuclear weapon tests, the dose from fallout, principally due to the long-lived fission product Sr90, has begun to assume significance. It is currently estimated that the deposition of Sr90 over the soil has added about 20 milliroentgens/year to the environmental dose over undisturbed land.

The dose to humans is on average much less, due to factors such as shielding by buildings, removal of Sr90 by rain, and burial during cultivation, and is probably of the order of 5 milliroentgens/year. Additional radiation is received from fission products deposited in the body. Sr90, which accumulates in the bones, is estimated to give a dose of 30 milliroentgens/year to the bones in which it is deposited. Averaged over the whole body, this amounts to perhaps 4 milliroentgens/year.

The only other fission product which makes a significant contribution is Cs137, but it constitutes rather less of a hazard since it concentrates in the muscles and unlike strontium it is fairly rapidly eliminated. Therefore, although it is slightly more abundant in the products of fission than Sr90, its contribution to the annual dose at the present time does not exceed 1 milliroentgen.

Other man-made sources such as luminous wrist-watches add a further 4 milliroentgens/year, making a total of 36 milliroentgens/year from man's activities, of which 10 milliroentgens is a direct consequence of fallout. This may seem small compared with the dose from natural sources of 100 milliroentgens/year, but it cannot be ignored when so little is known about possible harmful effects.

PEOPLE in the N-News

Solartron Electronics Instruments Ltd., have appointed a reliability engineer to their staff to ensure that the very high standards of reliability vital to instrument manufacturing are maintained. He is **MR. ANTHONY COCKLE**, previously with Vickers-Armstrong (Aircraft) Ltd., and EMI Electronics Ltd., with whom he held a similar position in guided weapon development. Thirty-four years old, he has been a member of the British Aircraft Construction Electronic Component Committee and was a founder member of the Ministry of Supply Guided Weapon Reliability Panel.

The Ministry of Supply announces that **MR. S. A. HUNWICKS** has been appointed director of Atomic Weapons (Development). Mr. Hunwicks, who was born at Teddington in 1911, joined the engineering department of the National Physical Laboratory in 1930. In 1939 he became a junior scientific officer in the armament department of the Royal Aircraft Establishment. In 1946 Mr. Hunwicks, then a principal scientific officer, was attached to the British Ministry of Supply Mission in Australia. He rejoined the Royal Aircraft Establishment in 1949 and he has been superintendent of projects in the armament department since 1954.

MR. J. W. ASHLEY, BSc, chief engineer of Atomic Power Constructions Ltd., since the inception of the company, has been elected to the board as technical director. Mr. Ashley heads the team responsible for the design and construction of the 500 MW nuclear power station now being built by the company for the Central Electricity Board at Trawsfynydd.

British Insulated Callender's Cables Ltd., have announced that **MR. F. V. THOMPSON**, FCIS, AACCA, has been appointed director of personnel, and has relinquished his position as secretary of the company. **MR. J. P. HOURSTON**, BCom, CA, who has been assistant secretary since 1946, has been appointed secretary. **MR. G. V. TEW**, who is a solicitor and has been on the legal staff of BICC for seven years, is now assistant secretary.

The third board of governors of the International Atomic Energy Agency, constituted during the recent third session of the Agency's general conference, has elected **MR. D. B. SOLE**, the governor for the Union of South Africa, as chairman, and **DR. KAREL PETRZELKA**, of Czechoslovakia, and **MR. ISMAIL FAHMY**, of the United Arab Republic, as vice-chairman.

MR. B. WILLIAMS has been appointed resident technical sales representative at the Bristol office of Crofts, power transmission engineers, of Bradford, Yorks., in place of **MR. DAWSON**, who has retired. He is apprentice trained and a graduate of the Institute of Engineering Designers. His experience has included ten years with a firm designing automatic packaging machinery, and he has recently undergone a period of training in power transmission equipment at Crofts head office and works.

MAJOR W. R. BROWN has relinquished the post of joint managing director of The Power-Gas Corporation Ltd., but continues as chairman. **MR. C. E. WRANGHAM** is now sole managing director of the company and continues as vice-chairman.

'NUCLEARIST' writes . . .

SAILING the seven seas produced abundant inspiration for rousing stories. The advent of steam robbed the oceans of much of their romance; gone were the long voyages, often lasting a year or more; gone were the heroic stamina of those who manned the windjammers, and the anxieties of the womenfolk who awaited their return home. Can it be that we shall soon witness the return of those epic days, with their tales of long separations and the bright eyes of those who listened to the yarns of the returning wanderers? We read of the Soviet ice-breaker *Lenin*, with its three nuclear reactors supplying 19,600 h.p. to the screws; its bulkheads enabling it to stay afloat even after a severe collision; its multipurpose clinic, with X-rays and dental rooms, operating theatre, isolation ward, and laboratories. Such thorough equipping can mean only one thing, and this is borne out by the fact that the ship can voyage for a year without refuelling. It means that once more we shall hear of crews who see little of their homes. Back to the old days again, it seems.

* * *

While on the subject of Communist ships, it is interesting to note that whereas many British experts, among them Sir John Cockcroft, have expressed their amazement at Soviet nuclear progress, the Russians themselves have little intention of resting on their laurels. They have admitted, in fact, that bad organization in various scientific institutions has resulted in a frittering away of effort and a lowering of technological standards. Consequently there is to be a reorganization of the Soviet Academy of Sciences and its allied institutes. Though this has a somewhat ominous sound, perhaps it will not involve such drastic action as some of the political purges.

* * *

I would like to express my sincere best wishes for the future prosperity of the newly formed Institution of Nuclear Engineers. As the first British-conceived atomic-age institution for those anxious to put their scientific and engineering knowledge at the disposal of the new technology, this Institution, with its promise of world wide membership, can do much to strengthen the bonds between nuclear workers. What I would like to know, though, will it, like the other scientific institutions in the fields of engineering, chemistry, physics, biology, and so on, develop into an examining body, offering opportunities for the acquisition of highly-coveted qualifications? And how will its associations with other bodies, especially those overseas, develop? The Institution could have a glorious future before it, and the opportunity to make its mark upon the peaceful applications of nuclear energy.

* * *

Now, back to my pet subject, nuclear education. The City and Guilds of London Institute has for some years been running a scheme for the training of chemical plant operators; a scheme which has been widely acclaimed by many manufacturers. Now, "at the request of the industry," atomic energy has been added to the subjects in which the students may specialize in their examination. Since the course is designed solely for those engaged in chemical plant work, it is legitimate to assume that the students will come from the UKAEA itself. This seems to suggest that the Authority has at last condescended to hand over to educational establishments at least a portion of the responsibility of the training of their personnel. This augurs well for the future of nuclear studies in this country. It will be very interesting to see how this new subject prospers, and I look forward to the early success of the first batch of guinea-pigs.

* * *

From guinea-pigs to mice, another rodent species, is but a short step. This animal, I understand, has been made the subject of some interesting experiments upon radiological protection in Japan. It has been found that the injection of a mixture of sodium and calcium citrates into mice previously treated with radioactive isotopes caesium-137 and zirconium-95 rapidly produce the elimination of 70 per cent. of these nuclides from the body. Although this result is promising from the scientific point of view it may be cold comfort to the mice, especially if the initial doses were so large that the remaining 30 per cent. left in the body proves lethal. This is something on which we may hope to hear more when Professor Ogawa, of the Japanese Pharmacological Society, publishes his final report.

* * *

Isotopes have struck the headlines also in the U.S.A. Lithium has always been looked upon as a comparatively rare metal, and yet even after removal of the 8.3 per cent. of lithium-6, the Americans can still sell lithium (Li7) quite cheaply. Thanks to the demand for this element in the nuclear industry, what was once sold in the ordinary form for some $300/gramme, is now obtainable, free from the Li6, at a very low price, The price has fallen sharply, and this makes the Li7 useful for reactor cooling, and in the form of some of its compounds, as a corrosion inhibitor for nuclear systems. The Li6 is removed because of its avid tendency to absorb neutrons.

* * *

Several U.S. reactors have hit the headlines recently too, Atomics International, of the U.S.A., is responsible for the 20-30 MW/e pilot-stage reactor for power programme development in Spain. The Junta de Energia Nuclear has chosen a heavy-water moderated type, cooled by organic liquid, and of multi-purpose design. The power production will reside in natural uranium oxide fuel which will enable the users to gain experience in fuel processing. "Spikes" of enriched uranium will provide a very high flux in the central hole. Each fuel tube will be an industrial process tube. The reactor will provide a test facility for nuclear fuels, and will have 15 thimbles for isotope production. A "rabbit" will be used for making short-lived isotopes. The Spanish Junta has wisely decided to have a very versatile reactor which will provide experience, training, irradiation and test facilities, and isotope production.

NUCLEAR NEWS

- **Canadian-Euratom Agreement** *(This page)*
- **American Scientists in U.S.S.R.** *(Page 602)*
- **Revised Core for Jap Station** *(Page 603)*

Transatlantic Pact

ATOMIC ENERGY OF CANADA Ltd., and the European Atomic Energy Community (EURATOM) have signed a technical agreement for a joint research and development programme centred on natural-uranium-fuelled heavy water-moderated reactors. Studies and development work will be carried out both in Canada and within EURATOM on heavy water-moderated, organic-cooled and heavy water-moderated heavy water-cooled concepts. Under the agreement AECL and EURATOM will also make available to each other information normally contained in scientific and technical reports and will exchange basic designs of power reactors and of reactor accessories and auxiliary equipment. The two parties will make equal contributions to the joint programme up to the equivalent of 5m. European Monetary Agreement accounting units (dollars) each, over a period of five years. A joint Board consisting of voting representatives of AECL and EURATOM in equal numbers will guide the programme through its course. By mutual consent, representatives of third parties may be invited to join this Board.

British Replacement

HUMPHREYS AND GLASGOW, Ltd., have announced that their agreement with Alco Products Incorporated, of New York, in connection with nuclear power station units of up to 30 MW capacity has been terminated by mutual consent. The British firm are now prepared to offer a similar range of comprehensive power stations incorporating pressurized water reactors designed and manufactured by Babcock & Wilcox Ltd., of London.

"Banshee" Production

PILOT production of "Banshee" fallout alarms by Tracerlab Inc. has started. The "Banshee" fallout alarm was developed by Tracerlab at the request of former AEC Commissioner, Willard F. Libby, and is designed for incorporation in civilian radio or television receivers to warn of the presence of dangerous levels of radioactivity following an atomic attack. In the presence of radioactivity the Banshee generates a signal which causes the loudspeaker of the radio to emit a high pitched wail. This signal is heard at every position on the radio dial and its pitch rises or falls with an increase or decrease in radiation.

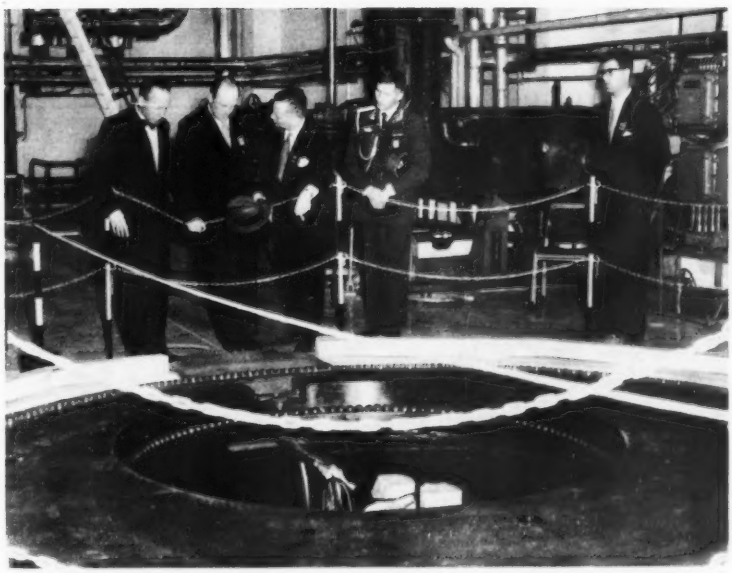
UKAEA Report

RECENTLY published by the United Kingdom Atomic Energy Authority is the "popular version" of the Authority's 1958-59 annual report, delayed by the printing dispute. Printed on glossy paper and profusely illustrated with line drawings and photographs it covers substantially the same ground as the official report except that the chapters on fusion and radio-isotopes have been altered to meet the requirements of space and presentation. Copies may be obtained from Government bookshops in London, Edinburgh, Cardiff, Manchester, Bristol, Birmingham and Belfast or through any bookseller, price 2*s*.

Electricity Show

AN exhibition emphasizing the part to be played by nuclear power in satisfying the long term increase in demand for electricity was recently held by the Central Electricity Generating Board at Trawsfynydd. It was staged in connection with the Trawsfynydd nuclear power station project and the pumped storage scheme at Ffestiniog. A dominating feature of the exhibition was an animated map which illustrated by coloured lights and a recorded commentary, the whole of the power system operated and controlled by the Central Electricity Generating Board in England and Wales. A series of panels depicted the history and development of nuclear power, and models illustrated the main power developments in Wales. Utilization of electricity, particularly in the domestic field, was represented by a selection of appliances and equipment arranged by the Merseyside and North Wales Electricity Board.

Halden's Royal Opening



His Majesty King Olav of Norway (*hat in hand*) takes a look into the reactor pit of the boiling heavy water reactor at the Instituut for Atomenergi, Halden, which he recently opened. With him are Institute Directors Gunnar Randers and Odd Dahl, the king's adjutant, Major Arne Haugh, and the Institute secretary, Bjarne Aabakken. The reactor, which is the first of its kind in the world, is owned by the Institute but will be used during the first three years of its operation for a joint research and experimental programme carried out by member states of the OEEC European Nuclear Energy Agency and EURATOM. Design specification of the reactor is 20 MW of heat produced in the primary circuit at a steam temperature of 230 °C., corresponding approximately to 30 kg/cm². It is intended to approach this specification in two stages, using different reactor cores for each stage. The first stage fuel will consist of seven tons of natural uranium. In the second stage it will consist of 1.5 per cent. enriched uranium oxide

U.S. Scientists in U.S.S.R.

The chairman of the United States Atomic Energy Commission, Mr. John A. McCone, and a group of American nuclear scientists recently visited Russia to inspect nuclear installations there. In this illustration (*from left to right*) Dr. Alvin Weinberg, director of the Oak Ridge Laboratory, Professor V. S. Emelyanov, Russian nuclear chief, Mr. C. McCone, Academician I. V. Kurchatov and Professor V. V. Goncharov, leading Russian scientists, are seen at the control panel of a research reactor at the Institute of Atomic Energy, Moscow. During their tour of the U.S.S.R. the American party visited *Lenin*, the nuclear powered icebreaker, the Leningrad Scientific Research Institute of Electro-Physical Apparatus where they saw ALPHA (the Russian ZETA), the Institute of Thoretical and Experimental Physics, Moscow, the various nuclear research laboratories at Dubna, and the nuclear power station at Obninsk, Some of the party also visited uranium mines and ore processing plant at Krivoi Rog

Article Prizes

THE scheme for awarding annual premiums for articles on electronics, organized in the past by the Radio Industry Council (London) is now under the joint sponsorship of the Council and of the Electronic Engineering Association. Articles published during 1959 will be considered by the panel of judges early in the New Year, and explanatory leaflets can be obtained from the Electronic Engineering Association, 11, Green Street, London, W.1, to whom also eligible articles should be submitted before the end of the year. Six premiums of 25 guineas are offered to writers not earning their living wholly or mainly by writing. The judges, headed by Professor H. E. M. Barlow, Professor of Electrical Engineering, University College, London, are given the greatest possible freedom in allocating awards, but main factors taken into consideration are:—the value of the article in making known British achievements in radio and electronics; originality of the subject; technical interest; and presentation and clarity.

Lead Film

INTENDED to interest non-technical audiences, the Lead Development Association's new film, " Lead, the Enduring Film Metal," offers general information on the metal. It briefly traces the history and ancient usage of the metal and then describes its occurrence in the world and how it is mined, smelted and refined. The main sequences of the film demonstrate the versatile role played by lead in the modern world and deal with its many applications, including its use in the nuclear energy industry as a radiation shield. The film is available in 16 mm gauge with sound track and has a running time of 28 min. Producers are Stanley Schofield Productions Ltd. Copies are available free of charge from the Lead Development Association, 18, Adam Street, London, W.C.2.

Nuclear Health

THE health record of the use of atomic energy is unrivalled in any other industry, Experts from many parts of the world who have recently held a week of discussions in Geneva on Medical Supervision in Radiation Work say this is because the potential hazards were so well understood beforehand. The dangers of radiation have been studied ever since X-rays and radioactivity were discovered in the last decade of the 19th Century. These studies and the experience doctors have gained using X-rays formed the basis of the highly successful health protection measures introduced at the start. " When there is an accident in an atomic energy plant, the man probably fell off the roof," one of the experts pointed out. This Expert Committee of the World Health Organization (WHO) was composed of nine doctors from Canada, France, Italy, Sweden, the United Kingdom, U.S.A and U.S.S.R. Its discussions were concerned with the medical supervision of persons working with all kinds of ionizing radiations, X-ray machine operators, research workers in university and other laboratories, hospital technicians, and employees in atomic energy installations. It was generally agreed that biological and social factors are the basis for recruitment and that there was little medical reason to impose one age limit rather than another, or to exclude women, in carefully controlled radiation work where maximum permissible levels of exposure are never exceeded. The members were in complete agreement that the health problems of radiation workers should be considered in their true perspective.

New Address

ELLIOTT BROTHERS (London) Ltd., a member of the Elliott-Automation Group, have announced that its branch office in South West England and South Wales has moved to 55, Westgate Chambers Newport, Monmouthshire. Telephone number is Newport 65710.

Colombian Institute

COLOMBIA has created the Institute de Asuntos Nucleares, an autonomous public entity that is to develop the study of atomic nuclear energy and to ensure it is used for peaceful purposes in conformity with international agreements. The institute will receive annual grants from the budget and take over the assets of the Colombian Atomic Energy Committee. The Government will consult the institute on official policy connected with the production, use, or exploitation of nuclear energy.

N-Submarine Takes to the Water

The " Polaris "-firing nuclear propelled submarine *Patrick Henry* when it was recently launched in the Thames River, Groton, Connecticut. Three hundred and eighty feet long and with a deadweight of 5,400 tons, this craft is capable of firing solid fuel missiles while submerged or surfaced

New Core for Tokai-Mura

A REVISED and improved design of the core structure for the 150 MW nuclear power station proposed for Tokai-Mura, 70 miles from Tokyo, has been approved by the Japan Atomic Power Co. The original core structure design submitted to the company by the GEC of Britain, with whom letters of intent for the construction of the station have been signed, allowed for dimensional changes due to thermal expansion and " Wigner " growth and at the same time took into account any conceivable earthquake hazard. Later experimental data confirmed that at high temperatures and after long neutron irradiation a shrinkage would occur in the graphite. Such shrinkage would give rise to the possibility that under extreme conditions of emergency the outer part of the core might be held tightly together while the inner part would become loose. Studies, therefore, had to be made on finding ways of overcoming this. The GEC core design which has now been approved meets all the requirements without involving any loss of power output. The core is constructed solely of layers of graphite bricks, the bricks being basically hexagonal in section but keyed to each other in such a way that they remain fixed together in their correct relative positions under all possible conditions of expansion or contraction. A supporting structure surrounds the cylindrical core, serving to prevent the layers moving relative to each other even in the event of a severe earthquake. Discussions have been continuing in Tokyo on certain outstanding commercial aspects of the contract. Although they are taking rather longer than was originally expected, these talks are proceeding satisfactorily, and present indications are that the contract will be ready for signing by the end of November.

New Harwell Course

NINETEEN standard or full courses have to date been held at the Harwell Reactor School, and Standard Course No. 20 will start on January 4th and continue until April 29th, 1960. Altogether, 1,004 students from 32 different countries have so far attended these courses, which began in September, 1954, and are designed to train engineers in the techniques of reactor construction and operation, particularly in connection with nuclear power stations. Half the places at each course are allocated to overseas students and a fee of £250 exclusive of accommodation is charged. A special course for senior technical executives will be held from May 9th to 20th, 1960. This is the tenth course of this kind and the fee is 50 guineas exclusive of accommodation.

Atomic Energy Office

WITH the appointment of Lord Hailsham as the Minister with general responsibility for science and technology, including nuclear energy, the Atomic Energy Office and the Lord President's Office will be combined. The new office will be in the charge of Mr. F. F. Turnbull, CB, CIE, whose appointment as Deputy Secretary to succeed Sir Friston How in charge of the Atomic Energy Office, was announced some months ago. It will be organized in two divisions—(1) a General Division, under Mr. R. N. Quirk, Under-Secretary, corresponding to the previous Lord President's Office: and (2) an Atomic Energy Division, under Mr. M. I. Michaels, Under-Secretary, corresponding to the previous Atomic Energy Office.

Bradwell N-Power Station

Construction of the £40m. nuclear power station at Bradwell, Essex, work on the site of which started in January, 1957, is six months behind schedule. The contractors, the Nuclear Power Co., Ltd., blame strikes and bad weather. They do not expect to be penalised by their client, the Central Electricity Generating Board, for the delay. The first part of the station will now probably be ready for operation in 12 months time instead of mid-1960 and the whole early to mid 1961. To date the structure of reactor No. 1 building and of the turbine hall is complete and when our reporter recently visited the site civil engineering on the spent fuel rod pond and the turbine cooling water system was nearly finished. In reactor No. 1 building stress relieving of the pressure vessel had taken place and pressure testing was to follow soon afterwards. Tubing of the six boilers had taken place and five of the six carbon dioxide coolant gas blowers had been tested and the burst slug detection equipment installed. In reactor building No. 2 the top cap of the pressure vessel had yet to be lifted into position and welded. Five of the six boilers had been erected and were in the course of being tubed. Work was proceeding on the blowers, control room, etc. (*Above*) Aerial view of the site showing the turbine hall, administrative blocks and the reactor buildings. The Goliath crane used for lifting heavy pieces of equipment into position can be seen straddling reactor building No. 1. (*Right*) The 12th and last 200 ton boiler shell arriving at the site after its sea journey from the Head Wrightson works at Thornaby-on-Tees. All 12 boiler shells for the station were fabricated there and then towed down to Bradwell down the North Sea. It was decided that the fabrication of these large structures could be better carried out in the controllable conditions of a works than on site and the sea offered the least complicated means of transport down south

N-Rocket Studies

LOCKHEED NUCLEAR PRODUCTS, a Branch of Lockheed's Georgia Division, have been chosen by the U.S. National Aeronautics and Space Administration Washington, to provide engineering data on a feasibility investigation into nuclear rocketry. Lockheeds were one of seven companies which submitted proposals to the administration for this project. It is expected to last for three years and cost over $1m. The main object of the work undertaken will be to determine the behaviour of possible nuclear rocket materials at very low temperatures while undergoing radiation exposure. The main part of the study will be carried out at the NASA's Plum Brook reactor facility near Sandusky, Ohio, where there is a 60 MW research reactor.

Reference Book Planned

IN preparation by Sir Isaac Pitman & Sons Ltd., by arrangement with the American firm of Prentice Hall International Inc., is the *Encyclopaedic Dictionary of Electronics and Nuclear Engineering*. This is a new giant reference book which is said to be the first to provide a complete and authoritative coverage of the entire field of electronics and nuclear engineering. A massive volume of over 1,400 pages, it includes over 1,400 illustrations and contains 1m. words and 17,000 cross-references. The Editor is Robert I. Sarbacher, a scientific consultant to the U.S. Armed Forces and to private industry.

Equipment and Materials

Items published in this monthly feature are compiled from manufacturers' current literature. Readers requiring further information should use the form at bottom of the page. Manufacturers are invited to send literature or details of their products for inclusion in this feature.

Isotopes by Air

An isotope container designed to conform to the International Air Transport Association regulations for the carrying of highly radioactive sources by air has been introduced by M. Falk & Co., Ltd. It is approved by the Ministry of Aviation under Authority AS/42/2/01. It is completely fireproof and is so made that one container can be stacked on top of another so as to save storage space. The container will take standard Harwell cobalt, iridium, thulium and caesium capsules as well as isotope capsules made in Canadian or European reactors. One type of container is fitted with suitable cavities to accept the standard

The M. Falk isotope container

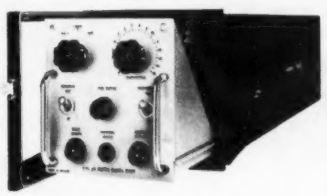
gamma-radiographic isotope containers of "Gamma-Rays" equipment with the isotope already fitted into the holder, while the other container is constructed to take only the capsule. The containers are available to carry either one or two isotopes and although the external dimensions are identical for all containers they vary internally according to the load, which can be as small as a few millicuries and as large as 3 curies of cobalt-60 or 500 curies of caesium-137. Weight of the container for taking the highest activity is 335 lb (150 kilos) and for taking the lowest 60 lb (27 kilos). **(DR 1)**

Simultaneous Deseaming

A deseaming machine of an improved design is now being marketed in this country by British Oxygen Gases Ltd. One of these machines, the first to have continuous orifice burners, has already been installed in the Bilston works of Stewarts and Lloyds, Ltd. The machine deseams all four sides of a bloom simultaneously. The deseaming process, a method of eliminating surface defects from hot steel blooms, involves the removal of the surface metal. This results in a continuous production of molten slag, and a feature of the new machine—the Lin-De-Surfacer (Type CM-27D)—is its ability to granulate the slag with water jets, thus protecting the rolls from spatter. Designed to deseam hot steel blooms by the oxy-acetylene process at the usual rolling temperatures, the machine accomplishes the operation by means of fully automatic deseaming units. These units are articulated so that they will maintain a fixed relationship with the bloom surfaces even though the bloom may have some vertical or horizontal camber. The machine is mounted upon a motor-driven carriage, which is installed transversely to the roll table line, and rides on rails. These rails are located so as to allow the machine to be positioned in line with the roll table or to permit its withdrawal for inspection. It is controlled from a special type of control desk. The operating cycle of the machine is governed entirely through electrical timers. **(DR 2)**

Reduced to Small Scale

The increase in the number of instruments required in modern process control has led to the development by Electronic Instruments Ltd., of a whole range of



The EIL miniaturized pH meter

miniaturized instruments for measuring temperature pressure, level and flow. The first Industrial pH Meter in this form is a miniature version of their standard Industrial pH Meter. It occupies 60 per cent. less panel area and may be used in conjunction with any of the conventional miniaturized recorders or controllers. The manufacturers state that well over 1,500 of their standard Industrial pH Meters have been installed during the last 12 years both in factories of all the major industries and on liners and tankers the world over. The performance of the Miniaturised pH Meter is identical to that of the standard instrument. **(DR 3)**

Cut along here

To: NUCLEAR ENERGY ENGINEER
147 Victoria Street, London, S.W.1

Please send further details of the following items in the EQUIPMENT and MATERIALS *feature for Dec., 1959*

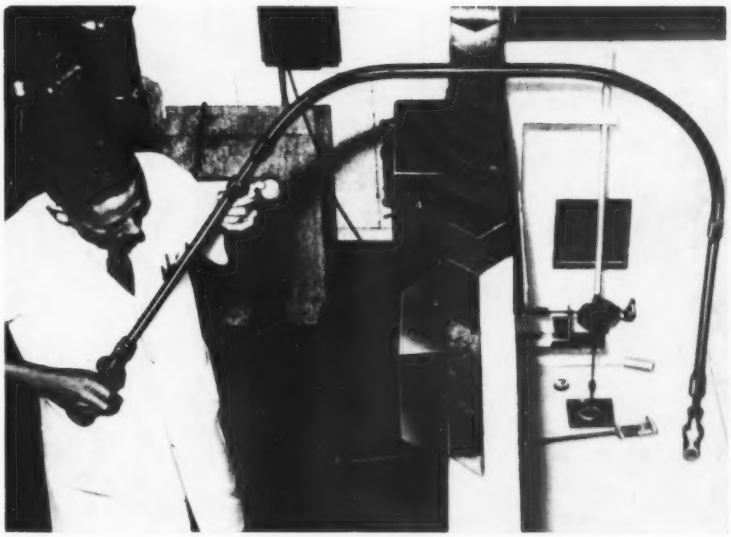
Item No's ....
....

IS THIS ENQUIRY CONFIDENTIAL? YES | NO

Enquirer's Name .....
Position .....
Firm .....
Address .....

Remote Handling Tool

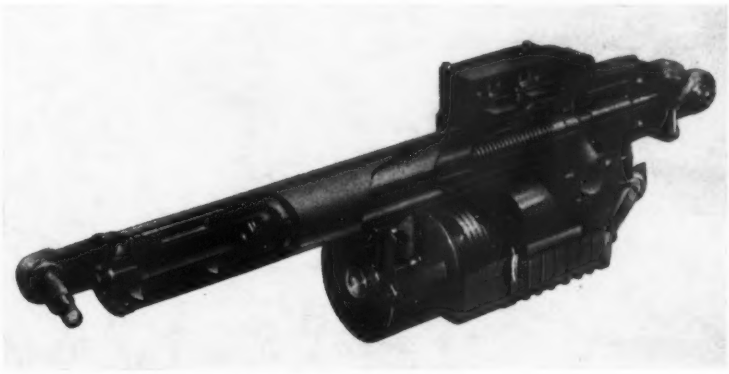
Teleflex Products Ltd., of Basildon, Essex, remote control specialists, have recently introduced a new device, the Overall Tong, to enable radioactive and toxic materials to be handled remotely and without endangering life. It obviates the necessity for remote handling at fixed stations, is sealed and does not require any maintenance. The unit can be used for gripping, carrying and rotating, and because it is virtually free from back-lash, is sensitive and positive in action. It was designed in conjunction with AERE, Harwell. The control mechanism comprises a unique flexible shaft, one end attached to an operating mechanism, and the other to a tong head. The tong head is closed by a trigger mechanism, fitted with a fine adjustment for positive grip, and is rotated by means of a twist grip handle. A quick release trigger provides instantaneous release of the tong grip. The body of the unit has an engraved scale of three markings, adjacent to the adjusting sleeve. Maximum and minimum fine adjustments of the tongs are indicated by red marks, and the intermediate position by a white mark. The support handle is adjustable for position and readily adapted to suit right or left-hand operation. A hook is provided for storage and also for the attachment of a pulley wire and counterweight if required. The weight of the units which are interchangeable is 6¾ lb. **(DR 4)**



The " Overall Tong " for the remote handling of radioactive substances

Electric Screw Jack

The Teleflex Linear Actuator made by Teleflex Products Ltd., of Basildon, Essex, is basically an electro-mechanical screw-jack for controlling mechanical movement. Advantages of this type of jack are that it does not require a separate power supply, maintenance and modifications to the system involve simple disconnection of a multi-pin and socket, and because the actuator incorporates its own transmitter, signals of precise movement can be relayed to the instrument panel without the need for additional outside linkages. The operating motor is normally wound for a three-phase 50 c/s, 400v supply, but motors for other voltages are also available. Full-load current of the motor is less than 1 amp. A special feature is that the actuator can be operated manually in the event of a mains failure. A plug-in handle is provided to permit independent drive and it can be used for setting up, when desired. Power output can be set to any predetermined value and can be varied between 40 and 4,000 lb. An overload device automatically stops the actuator and switches off the current in the event of a load higher than that specified being applied, thereby completely safeguarding the mechanism against excess loading. Cam-operated switches limit travel in either direction and are adjustable to suit requirements. They are fully enclosed, and visual indication of direction of travel is given through a window. A standard fitting is a twin disc brake, electrically released, to check over-run and to provide instant and positive locking at any position of the stroke. The actuator weighs 56 lb and has an overall length of 35 in. and a width of 5 in. The mechanism is fully enclosed and self-contained in a corrosion-resistant steel and aluminium case. The thread is fully protected by a steel outer shroud, with a wiper seal between the end-cap bearing and push rod. **(DR 5)**



The Teleflex linear actuator

" Pressure Moulded " Lead

A new lead brick for use in shielding personnel against gamma, beta, and alpha radiation has been produced by a special " pressure moulding " technique by British Lead Mills Ltd., a member of the Firth Cleveland Group. The company claims to be the first in the field with lead bricks produced by pressure moulding, which ensures the greatest density and freedom from porosity and at the same time meets with the stringent requirements of the Atomic Energy Authority. The bricks are produced in 2 in. and 4 in. thicknesses in the form of standard corner, top and bottom interlocking bricks. Half and quarter size bricks are also available. The Atomic Energy Research Establishment at Harwell have signed a two year contract with British Lead Mills for these bricks. **(DR 6)**

Vinyl Flooring Tiles

The administration building of the new nuclear power station at Bradwell-on-Sea, Essex, has been designed on the open plan system, with aluminium and Holoplast partitioned offices. The floor area of over 660 sq.yd has had to be prepared before the partitions are erected. It is laid with " Polyflor " vinyl flooring tiles. These tiles have been specified for their long life and hard wearing qualities and their resilience. The extreme flexibility of " Polyflor " allows it to be laid without previous heating, which reduces laying time and eliminates wastage. At Bradwell, three men laid the whole area using " Polyflor " adhesive directly on to a sand and cement screed on a suspended floor. Its resilience is such that the flooring will regain its normal appearance very quickly after carrying a heavy weight; where partitions may have to be moved as offices expand this is a considerable advantage. "Polyflor" is supplied by James Halstead Ltd. **(DR 7)**

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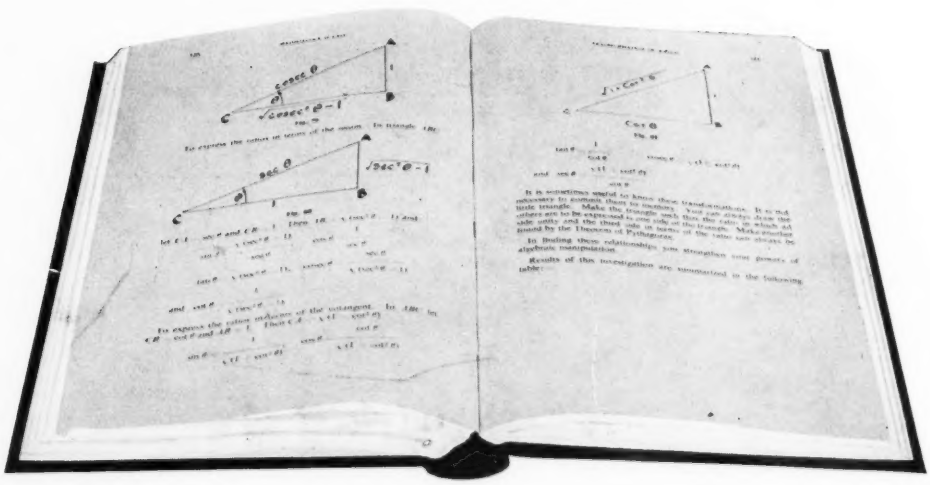
by D. S. Watt, B.Sc., M.I.N.A.



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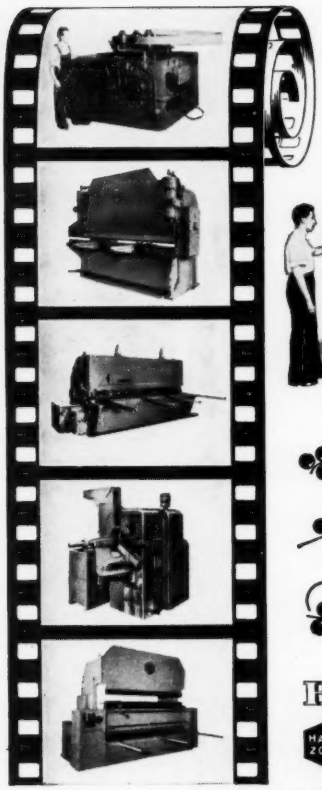

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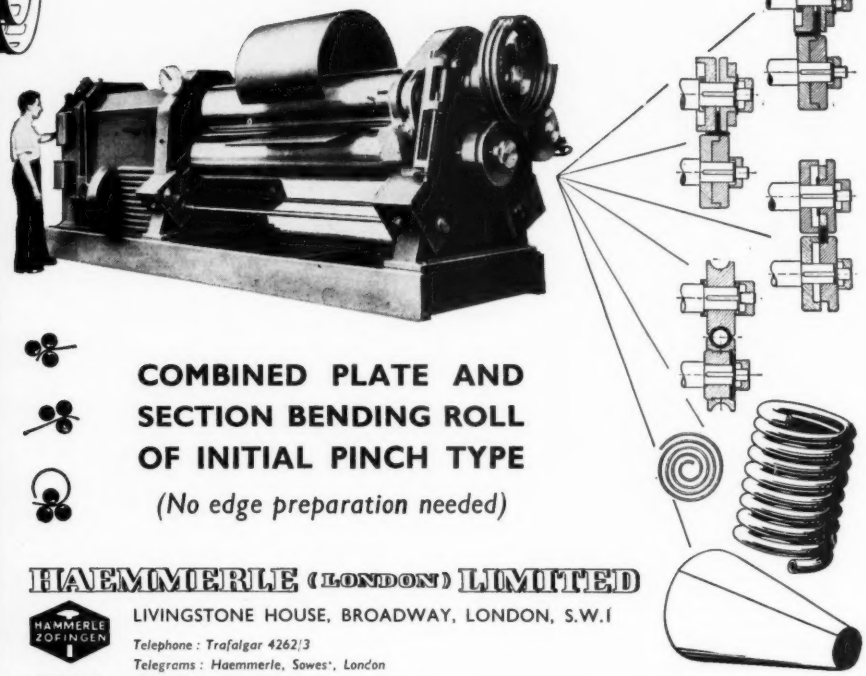

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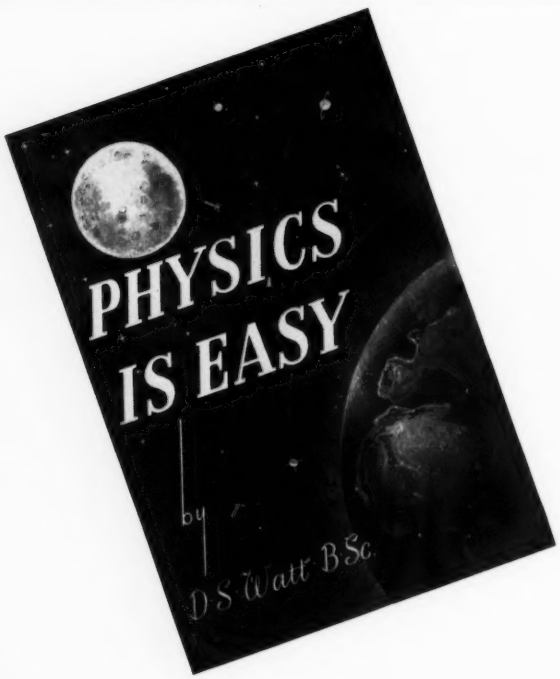

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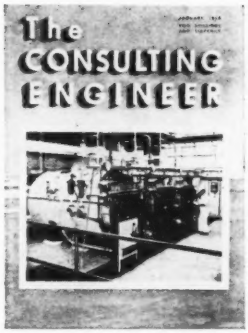

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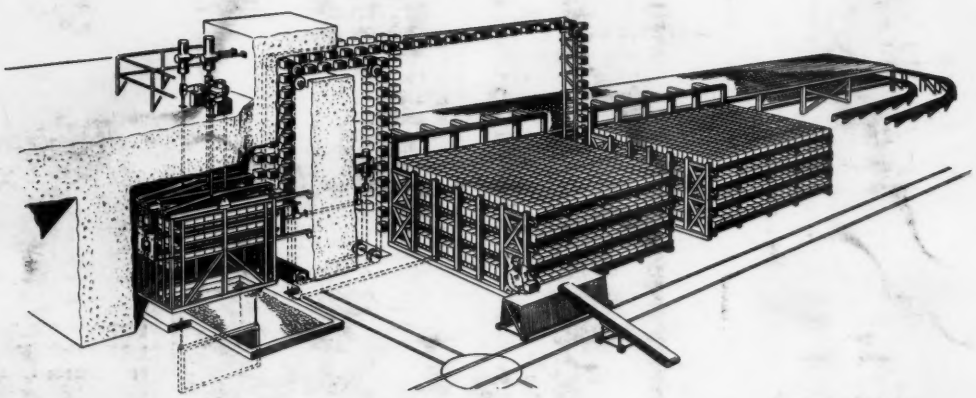

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